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Correction

In the February, 1953, issue of the Journal of Industrial Engineering, the name of the author of the article "The Importance of Accounting in Industrial Engineering," Mr. J. W. Caldwell, Associate Professor of Industrial Engineering at the Pennsylvania State College, was unintentionally omitted.

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MANAGEMENT AND INDUSTRIAL ENGINEERING

By H. G. Thuesen

Vice-President, Southwestern Region of A.I.I.E., and Head, School of Industrial Engineering and Management, Oklahoma A. & M. College

A great amount of effort has been expended upon trying to define engineering and industrial engineering. Much effort has been devoted to learning what engineers do. Surveys have revealed that engineering graduates in their first employment are usually engaged in activities that closely conform to the most easily defined aspects of engineering; namely, technical analysis, design and operation. These techniques are related primarily to the physical environment and its manipulation.

As time passes after engineers begin their first job subsequent to graduation, it is observable that most of them increasingly become engaged in activities that also relate to the social environment, or in other words, people. After a few years, many engineers are engaged almost exclusively in the direction of people, supervision or management, all of which may be termed management.

Many persons whose formal training was in engineering today manage people engaged in such activities as research, design, operations, and sales effort in relation to products of all grades of technical complexity. In fact, so large a percentage of persons trained in engineering advance to positions of management that the reaching of a position of management may be considered to be normal.

Is a person only to be considered to be an engineer to the extent that he engages in activities related to the manipulation of the physical environment; require knowledge of the physical sciences? If this view is taken, many persons who begin in engineering will leave the profession in the normal course of their development.

As a general rule, persons engaged in management activities appear to receive greater compensation and to have greater influence in regard to the utilization of engineering than do persons who restrict themselves to the application of the physical aspects of engineering.

To accept management activities as coming within the province of engineering, requires acceptance of the view point that engineering embraces the application of knowledge of the social as well as the physical environment. The knowledge required for management lies largely in the fields of physical science and social science. The manufacture of products by organizations usually involves a knowledge of what acts must be performed to the physical environment and then what must be done (direction, offering of incentives, etc.) to induce people to perform the required manipulation of the physical environment.

The basic physical science is physics (considered here to embrace chemistry). Certain aspects of physics have been abstracted and embodied in such engineering courses as mechanics, thermodynamics, electricity, hydraulics. These courses, although basically physics, have come to be known as engineering courses because they are taught, and used primarily by people who choose to call themselves engineers.

The basic social science is psychology, (here considered to embrace sociology). Psychology is concerned with the behavior of people. The person who knows what stimuli must be applied to induce required responses has knowledge basic to management.

Now psychology has barely scratched the surface and many consider it with misgivings. Nevertheles, psychology is fundamental in respect to the behavior of people. It is true that persons inherently sensitive and experienced in human understanding often are able to predict responses to stimuli more accurately than do learned psychologists. A similar situation exists with respect to any new area of inquiry and even in the more advanced field of engineering, many young graduates have been annoyed when practical engineers demonstrate abilities to guess results as well as the former could calculate them. But the point to be made, is that if engineers borrow from psychology and put it to work, it properly becomes an engineering subject in the same way that physics that underlies mechanics, thermodynamics, and electronics have become engineering. .

In sanitary engineering, engineers have borrowed from the biological sciences and thus certain aspects of them have become so closely associated with engineering practice that many engineers and others consider them as being within the field of engineering. A similar pattern is now unfolding with respect to certain aspects of economics in the subject known as engineering economy which is usually taught to engineering students by engineers. Economics is basically a social study in that it relates primarily to the behavior of people in relation to scarce goods.

In this connection, engineering seems not to be a science in itself, but the application of knowledge wherever it is found. It is interesting to note how engineers have arrogated certain areas of both the physical and the social sciences as needs for doing so have arisen.

From the fact that a large percentage of persons educated in engineering become engaged in management activities, it seems logical to assume that engineering education is of value in performing activities related to the behavior of people, management, as well as those relating to physical environment.

Since engineering education constitutes efficacious preparation for management and since many persons become engaged in management activities as an outgrowth of activities related to the physical environment, it seems logical and forward looking to consider management activities as coming within the field of engineering.

The basic activities which differentiate the work of industrial engineers from that of other engineers are such activities as time and motion study, tool design, factory planning, economic analyses, cost accounting, quality control, production control and wage administration. These activities have the common characteristic of being management techniques, all are concerned with the direction, control and utilization of acts of people; that is to say, they are management activities.

Professor Rubey, in a recent paper, states:* "A promising movement for our country lies in that new profession of management, largely practiced by engineers, which is motivated by a drive to make man's work effective rather than by the older drives for financial or political power. With professional management and technology, America's future is assured. Other national policies and procedures then will trend naturally into desirable patterns."

"Unless engineers and engineering educators seize and answer this call to leadership, others will grasp and exploit it. Then the engineering profession, engineering education, and industry will have missed a great opportunity. As a final thought, if more engineering graduates become managers, then more support for engineering education will be forthcoming."

Industrial engineering is an outgrowth of the attention directed to management by Frederick Taylor, an engineer, by training. In A.I.I.E., let us build the profession of industrial engineering on the broad base of management.

*Rubey, Harry, Journal of Engineering Education, V. 43, N. 5, Jan. '53.

Development and Charting of Predetermined Time Data

By D. G. Stohlman

Director of MTM Division, Serge A. Birn Company, Louisville, Kentucky

Primarily, all pre-determined time systems are standard data which have been compiled in various forms for easy reference. The charting of the data depends on the definitions and composition of each time element, in accordance with the background material employed in the development of the specific pre-determined time system.

The use of curves, charts, graphs and tables is an integral part of the system to explain pictorially the development of the individual time elements.

Since each of us prepares data in accordance with how it is to be used and who is going to use it, most data from which incentive standards are to be set are presented in table form. Although the engineer will develop curves and graphs to save valuable engineering time, he will normally transfer such information to tables to reduce the administrative and clerical time to a minimum. For example, all wage rates, insurance premiums, taxes, fares and the like are presented in table form to facilitate administrative procedures.

From the evidence—the actual presentation of the data by the various authors of pre-determined time systems and the use of tables by clerical personnel—we can conclude that the use of tables is peferred to such other forms as charts, graphs, curves and diagrams. It is true, of course, that each presentation has its special merits, and the use of each is advisable during the development stages. However, once the data have been developed, experience indicates the desirability of presenting the final results in table form.

Much has been written about the pros and cons of pre-determined time systems. What many of us may not know or realize is that the worth of any procedure, system or creed lies basically in the faith the user has in that procedure, system or creed. Time study, too, has its believers and non-believers. So, if we believe in the basic premise of pre-determined times, we may then develop standard data which will provide a greater degree of consistency — uniformity of individual rates — because of the minute elemental breakdown.

Because we can visualize an operation—and because we can develop very small and flexible time elements, considerable time can be saved in the development of standard data through the use of pre-determined time systems.

The examples presented in this article cover two areas—data based upon manual motions and machine time and data based upon process controlled motions. Since basic feeds, speeds, cutting times and the like present no problem with respect to measurement, no example is included.

All the data contained herein were derived by using only one of the pre-determined time systems — Methods-Time Measurement. The methodology, however, is applicable to the other synthetic time study systems.

Since the use of pre-determined times permits a very close and exacting methods analysis, the probability of incorporating inconsistencies and human error is radically reduced. The very fact that each motion must be subjected to critical analysis provides the engineer with safety insurance on the reliability of his data.

Further, since the engineer can develop the best manual motion pattern for an operation, he realizes that machine times and partially process-controlled times must be subjected to this same searching analysis. How many times have we asked ourselves: "How long should it take to sand, to buff, to grind, to polish, to rub, to iron, and the like?"—or—"How long should it take to saw, to rout, to cut, to shape, or to form some piece of metal or wood?"

Therefore, we have to go further into the problem of process controlled operations. We cannot afford to accept an overall watch reading—even though tempered by good experience and judgment—as evidence of the true or average time. We must "engineer" this time. To do this, of course, involves fine measurement. Pre-determined times, although no panacea and certainly not the final solution, offer a sound systematic approach to the field of process controlled or partially controlled manual motions.

Although the accompanying data is in use and has proven to be consistent, it is not reproduced herein as a final answer. The results attained by the Company of origin prove merely that the data apply to their operations, not necessarily to similar operations in other industries. In spite of the rapid advances made in the development of standard data through the use of pre-determined times, we may only use data developed at any given source for that given set of conditions. If conditions are identical from plant to plant, then the data may be used. The approach would be the same, but method change, layout, working conditions, condition of machinery, etc., would all have to be measured independently before the data could be approved as applicable in other industries.

The following example of the zipper cutting operation provides a very simple approach to the setting of standard data. It was chosen, not because of its simplicity, but because it embodies all the principles involved. You will note that this operation entails only two variables—by this we mean, only two motions are subject to change in time values. In this instance, the variables are the distance the hands reach for a new length and the distance involved in moving various lengths to the die position. All other motions have a constant time value since each motion much be performed irrespective of the length of zipper.

Zipper material comes to this operation in a continuous strip rolled into a coil. Teeth are removed from the strip for a space of one inch at intervals which are dependent on the length of zipper to be cut. Each coil of zipper material is cut for 1000 zippers. The elements of the zipper cutting operation are as follows:

	Element	*Occur./Zipper*
1.	Make last cut on coil	1/1000
2.	Get new coil and make first cut	1/1000
3.	Cut zipper	1/1*
4.	Aside 20 zippers to basket	1/20

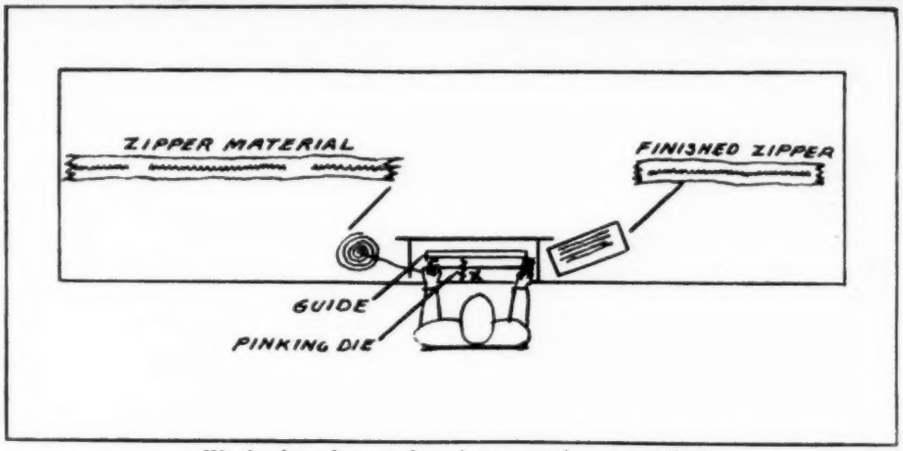
*Except last cut of coil

It can be seen that Elements 1, 2, and 4 are constant for all zipper lengths. Element 3, however, is a variable, being dependent on the length of zipper being cut. For the sake of brevity, only this element will be time synthesized in developing the standard data formula for the operation.

A close study of the operation is necessary for accurate assignment of pre-determined time values. Notice in the accompanying operation layout sketch that the operator keeps the end of the coil of zipper material in the left hand. The cutting element consists of movements necessary for the right hand to reach to and grasp (at point X) the end of the tape in the

left hand, to then pull the tape through the fingers of the left hand in moving to point B, as the left hand moves slightly to point C. Then, both hands align the zipper material in the pinking die just as the operator starts to depress the foot pedal to actuate the press and cut the material. After the material is cut the right hand palms the cut length and the cycle is repeated. When twenty zippers are accumulated in the right hand, it places them in the finished work basket.

The MTM analysis of the cut zipper element (Element No. 3) is as follows:



Work-place layout for zipper cutting operation.

Left Hand	TMU	Right Hand
Move end of coil to point X (M3A)	variable	Reach to tape at point X as finished length is palmed (R-A)*
Hold end of tape at Point X	1.7	Grasp end of tape at point X (G1A)
Move tape under die, allowing material to slip through fingers (M3C)	variable	Move to point B (M-C)*
Align tape with pinking die (P1SE)	5.6	Align tape in pinking die (P1SE)
	7.1	Actuate press (LM6)
	5.0	Press stroke (timed)

Total constant for element 3=19.4 TMU, for all zipper lengths.

*By actual measurement of right hand knuckle travel in cutting various lengths, the distance of reach and move was found to be equal to one inch less than the zipper length.

Assume the constant times per unit for Elements 1, 2, and 4 total 2.0 TMU per zipper. The total constant time per zipper for the four elements is therefore 2.0+19.4 or 21.4 TMU. Now, a formula for the total cycle time per zipper can be developed as follows:

Cycle time = Constant time + variable time
= Constant time + reach time + move time
= 21.4 + R(L—1)A + M(L—1)C where L represents the actual length of zipper teeth.

For example, 10″ zipper:

Cycle time = 21.4 + R(10—1)A + M(10—1)C
= 21.4 + R9A + M9C
= 21.4 + 8.3 + 12.7
= 42.4 TMU

Using this formula a listing of the standard for the various zipper lengths can be quickly prepared.

Since pre-determined times do not directly measure machine or process time, any chart or formula for such elements must be based on experience or experimental data. As applied to job methods it must be remembered that experience is "what was done," and is rarely "what could or should have been done."

Such was the case at Mississippi Products, Incorporated, Jackson, Mississippi—one of the largest furniture manufacturers in this country. Here the problem was one of developing consistent cutting times for router machines—woodworking machines used for grooving and interior cutting.

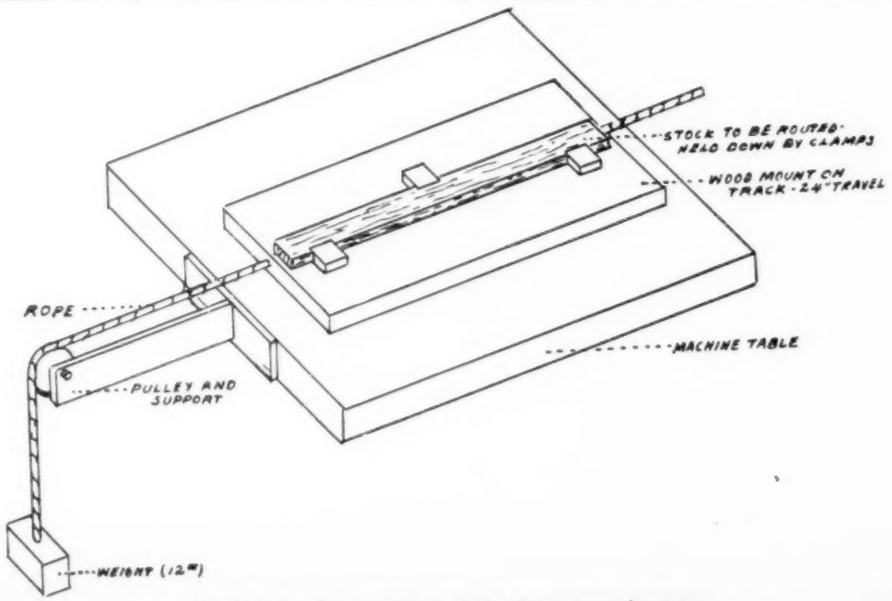
For this purpose, experiments were conducted to determine the relationship between router bit diameter and depth of cut for various species of wood. Equipment employed consisted of a standard 5 hp Model 240D, Onsrud router and ¼″, ⅜″ and ½″ diameter Onstrud standard H.S. single edge bits. The species of wood used in the experiments was gum and oak. The experimental process was as follows:

1. Insert selected bit and set the desired depth of cut.
2. Place the wood to be used in the form and clamp.
3. Pull the form to starting position.
4. Depress the router pedal to start.
5. Release the form.
6. Time, with stop watch, the travel of the form (pulled by the weight) from the moment of release until the form is stopped by the retaining rope (see sketch).
7. Repeat as desired.

As a result of these experiments, it was found that the time for cutting increased proportionately as the depth of cut increased. Cutting with or across the grain as well as the cutting of oak versus the cutting of gum bore a direct relationship to the quality of the cut required. Quality factors were determined in much the same manner as depth of cut.

Since the balance of the operation could be measured with MTM, it became a relatively simple matter with

(Continued on Page 20)



Equipment for router cutting time experiments.

QUALITY CONTROL IN MANPOWER

By Joseph E. Moore

Professor and Head, Department of Psychology, Georgia Institute of Technology

Why not more concern for the quality of manpower?

Management would not invest in a piece of equipment costing a hundred thousand dollars without a very careful evaluation of the merits of the machine. It would try to get adequate facts about performance, maintenance, and parts. Management would also require demonstrations or would visit other plants where the machine is operating and observe it. In short, management would be concerned to exercise sound, hard-headed judgment and would make investments only in quality machines and equipment. But does this same critical attitude carry over into the manpower field?

Human Misfits Wholesale

Quality control standards in manpower are needed, judging from the waste to be cited here. A year or so ago McMurry made a study of 1,167 college trainees chosen by 247 chemical companies over a period of thirteen years. He reported that only 58% of the group was judged suitable after one year. The training cost averaged $2,750 per individual or a total $1,347,500 to those companies.

No company can afford such expensive waste in manpower over any period of time. It is evident that such costs should persuade management to improve its procedures for selecting personnel. There is increasing proof that they are getting concerned.

For example, in the office personnel field Giese made a two-year fellow-up study of one plant to see how tests could have prevented certain misfits. His results led him to state, "When the results of a sound psychological testing program are measured in terms of dollars and cents, the potential in cost reduction for this plant reached $40,000 per year."

Numerous other examples of human waste could be cited, but what is needed is to see what preventive steps are being taken. One preventive step to reduce waste and to increase the quality of workers entering industry is to administer various psychological tests to them.

Does Testing Pay Off?

The answer to this question is yes most of the time but not always. Tests are not panaceas for all the ills of employee-selection programs. Tests are tools of selection and, when properly administered, accurately scored, and interpreted with understanding, can generally more than pay their way. However, rather than deal in generalization, let us turn to the experience certain firms have had with tests and get their reactions to them.

The learning costs for loopers in a hosiery mill were reported by Dr. Joseph Tiffin to vary from $135 for those scoring fastest on a dexterity test to over $600 for those scoring lowest. The use of dexterity tests could have saved $465 per employee by eliminating those who were slowest and selecting those who were fastest.

"Allis-Chalmers started its engineering training program more than forty-two years ago and has followed a policy of continuing to improve it from time to time. Perhaps the most important of these advances occurred four years ago when we started to administer psychological tests to some of the young engineers on our graduate training course after they were employed. This gives us an invaluable scientific basis for counseling them and guiding them into the right assignment among numerous types of work available in so large and diversified an organization as Allis-Chalmers."

The Dixie Cup Company reported that one test saved them over $7,800 in selecting female employees for one job.

In a machine shop operation Michael reported that in applying psychological tests to 88 applicants this company saved $2,035 by selecting only those who met their standards. This company also reported that tests had been a big factor in dropping the turnover rate more than 74 per cent in five months.

The Hamilton Watch Company reported that tests were being used to select engineers. Their experience with tests enabled them to improve personnel selection over 26 per cent.

The testing program at the Union Bag & Paper Corporation at Savannah, Georgia, proved so valuable that the following statement was inserted in the company's 1946 annual report: "The scientific induction tests which are given to prospective employees are proving particularly valuable in determining the suitability of the job to the capabilities of the applicant."

Growing Use of Psychological Tests

The information obtained in recent surveys shows that psychological tests are being utilized more and more by management to evaluate the qualities of employees. For example, a recent study was directed by Professor R. F. Wallace covering the personnel practices of 280 industrial firms. Table I presents the extent to which companies are making use of psychological tests.

Transfers and Promotions

The use of psychological tests to select employees is only the very beginning of a useful program. Test results may assist the personnel director in transferring employees from one job to another. In this manner workers may be transferred to jobs that challenge their ability. Some employees fail because they get bored with details too simple for their mental capacities. Similarly, men work under strain and often fail when they are placed in tasks too difficult for them.

The selection of employees for upgrading and promotion is in many instances the most important personnel step that management takes. To make intelligent selections for upgrading workers requires a careful analysis of many facts, because of the possible effects on plant morale. Objectivity, therefore, is vital. Mental test ratings, aptitude and achievement test scores, and performance or production records generally give a fair and objective basis for promotion. One investigator has studied the value of aptitude tests for selecting supervisors. His study included three different aircraft engine and propeller plants, and he concluded: "The promotability of minor supervisors such as group leaders and job setters was found to be related positively and significantly with test scores."

Cost of Poor Employee Selection

Errors in failing to select good workers cost industry an enormous amount of money. It is difficult, if not impossible, to approximate the picture of the total cost to management. However, it is possible to get some examples of what particular plants consider their selection and training costs to be.

William V. Machaver, Training Director for Johnson and Johnson, reported that "A new employee costs our company about $250 before he becomes a productive worker. Every time a new man is hired and is not properly placed in a job, it costs the company at least $250. If the man is then transferred to another job and fails again, it will cost the company another $100 to $150."

To get some conception of what the saving in training cost alone could mean to management, let us review a few typical samples. It can not be

stressed too strongly, however, that the mere application of tests does not guarantee good results. In a study of supervisors in an aircraft plant, one author warned against jumping to conclusions when he stated: "It will be noted that the differences in test scores all favor the good supervisors, that is, that they appear to be more intelligent, more stable, more dominant, more self-confident, and more sociable; but no difference ever approaches statistical significance."

A study made in the Indianapolis plant of the Radio Corporation of America may also be of interest. This study dealt with the selection of certain radio tube mounters and concluded: "Low intelligence scores tend to indicate the poor worker. Average or above average scores did not discriminate between 'good' and 'fair' workers. All workers scoring below average in social adjustment had been rated only 'fair' by the supervisor, while all workers scoring above average in social adjustment had been rated 'good' by the supervisor. The supervisor had no previous knowledge of test scores."

In a study of 99 foremen, Shuman found that mental ability scores and performance ratings by management agreed fairly well with each other.

Twenty-five executives rated as either superior or average were given a mental test. The superior executives were reliably faster and more accurate on the learning ability tests than were the executives rated as average.

Lawshe reported on a study of 176 supervisors drawn from 44 different industries. These participating companies were asked to identify two of their "poorest first-line supervisors" and two of their "very best first-line supervisors." These men were given a short 60 question paper and pencil test of mental alertness designed for use with adults in industry and business. Stated simply, the results of the study demonstrated that in so far as these 44 plants are concerned, the higher a man scores on the test the greater probability that he will be considered as being one of the best supervisors. Certainly mental ability appears to be one of the common denominators of supervisory success.

Selecting Clerical and Office Personnel

Unfortunately, too little attention has been given in the past to selecting clerical and office personnel. Very frequently a receptionist or a secretary must greet and receive important customers. She must frequently keep them happy and reasonably contented until her employer can see them. In fact, the secretary frequently gives the customer the basic all-important "first" impression of the organization. A wide range of abilities are required for different kinds of clerical jobs, and no one clerical test can be expected to be suitable for measuring more than a very limited range of such abilities.

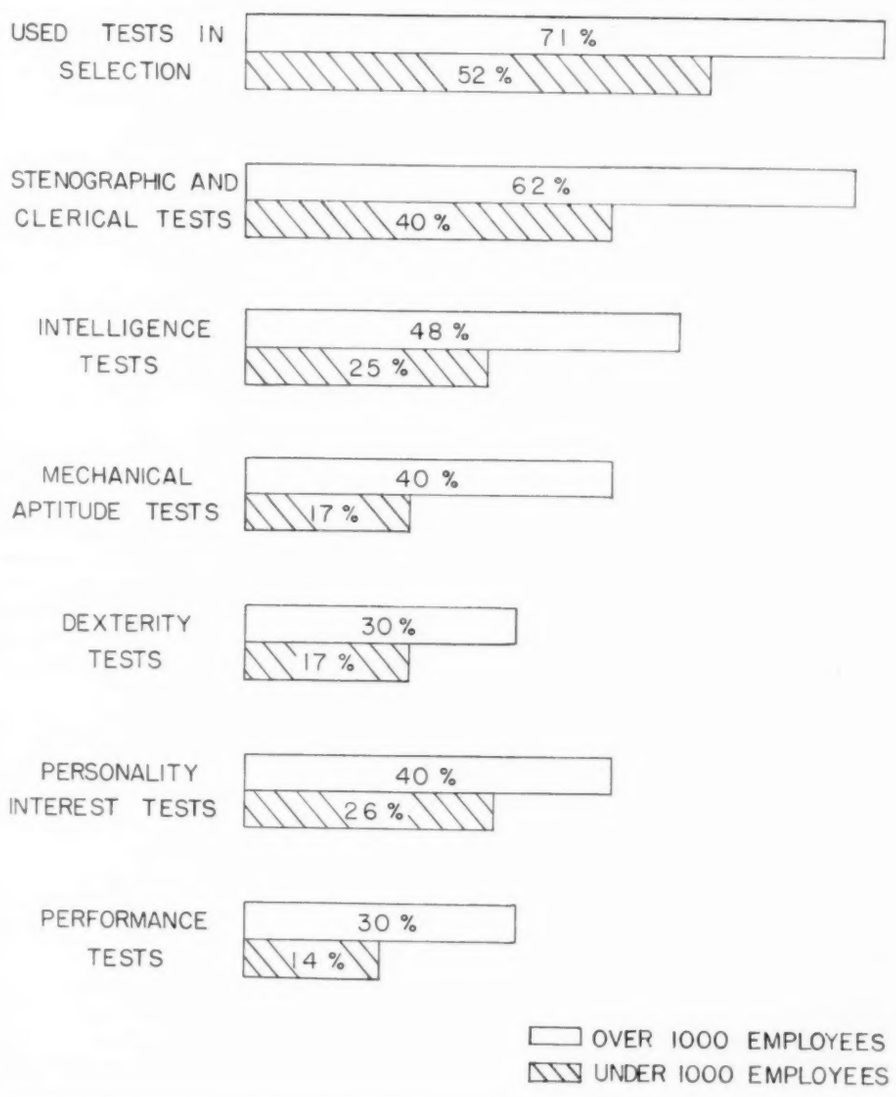
Learning-ability tests have demonstrated their value in helping to select and place employees in clerical positions. McMurry found a rather favorable agreement between scores on a test of learning ability and job efficiency in clerical work. Pond & Bills found that applicants for certain types of clerical jobs could be placed very satisfactorily. These investigators found that very difficult clerical work demanded people who could earn high scores on a learning-ability test. Individuals who made low scores on learning-ability tests when they were selected tended to remain in jobs calling for low skills, whereas, those earning high scores tended to be promoted to more responsible jobs. They also reported that work calling for simple learning ability and many repetitive operations or procedures seem to cause a very high turnover among individuals with superior learning ability.

In a study of office managers those who made the most mistakes and were criticized most often by management were those individuals who had also missed the most items on learning-ability tests. In a similar study, employers rated their clerical staff as either satisfactory or unsatisfactory and then gave them a learning-ability test. The results indicated that a score of 25 on this rate-of-learning test actually selected 86 per cent of the group desig-

(Continued on Page 24)

TABLE I

THE USE 280 COMPANIES MAKE OF PSYCHOLOGICAL TESTS



A MULTIDISCIPLINARY ANALYSIS OF ORGANIZATION

By K. T. Korn

Senior Associate, Edward A. Berk & Associates

The problem of organization is one with which every "manager" is faced. Moreover, it is one which is never really "solved." The question, then, arises: "What is the function of organization?" If organization is merely the definition of the performance of specified tasks by specified persons acting in accordance with specified patterns [as the conformance to routines and procedures], then it *is* possible to merely write these specifications, make the assignments, draw an organization chart, frame it, display it on the wall, and sit back—in the expectation that "everything" has been taken care of.

If, however, the policy-makers of an industrial or business enterprise look upon their business as a *complex, living organism* which measures its ability to adjust to changing conditions, to meet such infinitely altered situations, and which uses such measurement as an evaluation of the effectivenes of its organization, then, the question of organization becomes more complicated, and requires far more fundamental treatment tending toward attainment of the goal of increased organization effectiveness.

The organization of one industrial enterprise was studied by a multidisciplinary management research team[1]. The activities of the company were conceived as a process. A *process* is a set of simultaneous and consecutive steps tending toward the attainment of a final state or goal.

At each step there may be a set of alternatives, among which *one* eventually becomes the next step of the process. In the type of process in which a business and industrial enterprise is involved, each step is the result of a *decision*; that is, the selection of one from a set of alternatives. The efficiency of the process can be defined in terms of the contributions which the decisions make toward the likelihood that desired goals will be attained.

A company's goals, for example, might be (1) to make a profit, (2) to provide jobs, (3) to produce a product, (4) to utilize skills, (5) to market skills, (6) to provide the consumer with goods, or services, (7) or to remain in business by providing a "reasonable" return to the investor. These are a few of a possibly indeterminate number of goals a company might have.

This process can be studied with respect to (1) the individuals and groups who perform it; (2) the equipment employed in its performance; (3) the structural and functional organization of the individuals and groups, and finally (4) with respect to the process of decision-making which is traditionally employed.

The concept "organization" refers to the degree of inter-action among constituent parts. This may be expressed in *functional* as well as *structural* terms. The *functional* aspect of organization refers specifically to a division of labor among and within departments. The functional effectiveness of organization is, in turn, a function of the chain of communication, and the explicitness with which both authority and responsibility are (1) defined, (2) delegated, (3) accepted, and (4) executed; that is to say, a line of authority must be clearly and precisely indicated and must coincide with the line of responsibility flowing in the opposite direction. The *structural* aspect of organization refers to these lines of authority and responsibility of which an organization chart is a graphical representation.

Authority without responsibility for the results of one's actions is demoralizing. Responsibility without authority to carry out the tasks for which one is responsible is not only ineffective, but degrading.

By far the most complex aspect of organizational activity is the *process of communication.*

Communication with the past can be described as the use of past experience in the solution of present problems. Such communication depends on the existence and availability of records which are both descriptive and evaluative. Communication in the present is the transmission of information *within* groups. This involves a knowledge on the part of each individual of what his task is, and how it is related to the group task. Moreover, it involves a knowledge on the part of leadership of how the tasks are being carried out. Second, communication in the present concerns communication *among* groups. This involves a knowledge on the part of each group of what its task is and how it is related to the tasks of other groups and to the total task of the entire organization. Logically, it involves a knowledge on the part of top management of how the group tasks are being carried out.

Not all communication is strictly *informative.* An important aspect of communication is the formation of an "outlook" in an individual, that is his *orientation,* as a member of an organization. Important complements of this sort of communication involve a knowledge on the part of each individual of where and what information is available. It also involves such "intangibles" as morale of the individual, for example, a knowledge of the opinions which other members of the organization hold of him, social intercourse among members, etc.

Communication to the future is the systematic recording of present experience in a form such as to *increase the efficiency of future decisions.* Paralleling the internal communication system of an organization, there is a similar external communications system whose components, advertising, public and trade relations, and research, are largely self-explanatory. It is not quite so commonly recognized, however, that personnel policy and procedure can be designed to provide channels of communication to the outside.

An organization, in the pursuit of its objectives, is constantly confronted with the necessity of making decisions. Thus, the *notion of decision-making is inseparable from that of objectives.* Hence, a clear formulation of the objective is prerequisite to effective decision making. The common sense notion of clarity which often involves such things as grammatical elegance, abundance of dictionary-style definitions, etc., is not sufficient. What is required is a formulation which enables everyone involved in a decision to *evaluate alternative courses of action* relative to the objectives, and furthermore, to recognize the degree to which the objectives have been approached. For example, to say that "more cooperation" is an objective is to provide no basis for the evaluation of a program. On the other hand, if one specifies how, through a division of labor, the efficiency of a given task can be increased, one gives an expected measure of cooperation. Similar considerations apply to other phases of formulating problems, and to the formulation of methods of solving problems. It is emphasized that the verbal formulation of a solution to a problem does not render the problem solved. The decision associated with the solution must be carried out.

This perhaps establishes that "organization" is inseparable from "communication," that "communication is difficult, if not impossible, without "orientation," and that finally no effective process of decision-making can evolve without the others.

Basic to both *functional* and *structural* aspects of organization is the provision for planning, execution and control on *all* organizational levels, both *vertically* and *horizontally*. By "vertical" is meant from echelon to echelon, up and down; by "horizontal" is meant within echelons.

Planning implies, first, the definition of goals; second, the enumeration of alternative courses of action toward the attainment of these goals; third, the choice of one alternative which will achieve the goal most efficiently. *Execution* implies following the plan neither so rigidly that exingencies are not allowed for, nor so flexibly that the plan is altered in its basic conception. *Control* implies the provision, first, of adequate feed-back, and second, for predetermined criteria by which the plan *and* its execution can be evaluated.

Planning must start from the top down, rather than from the bottom up. It begins with the recognition and formulation of generalized company aims and goals which must form the foundation of the what, the how, and the why. It is obvious that the operations of a company will vary upon the emphasis placed upon any one, or any combination of aims, although it is equally obvious that unless the company remains solvent, none of the other aims can be achieved. For example, if the *primary emphasis* in a company is upon *providing jobs* (as it might be found in a paternalistic company culture), and the *second emphasis* upon marketing a product with *de-emphasis on making a profit*, then the attainment of the primary goal precludes the attainment of the others. Again, it is not enough to produce verbal agrement.

A company president may *say* that it is his primary goal to make a profit, the examination of policies and decisions however may indicate that benevolence dominates decisions. This may be illustrated by cases where a company was reluctant to retire an employee because he was indebted [a mortgaged home], by the character of the organization where the stockholders are also the managers. In this case no *outside* pressure is provided to operate at a profit. Another reason may lie in the personality characteristics of the persons who dominate the cultural structure of the company. For example, should the top-level management of a company be characterized by an *autocratic* orientation, policy is laid down by directive from above, there is little delegation of authority, and *all* employees, even at the top echelon are held strictly accountable to the top executive for the execution of their responsibilities. Personnel would be selected, either consciously or unconsciously, to insure *maximum submission* to the authority in command, and *minimum deviation* from the policy line.

In a company where top-level management is characterized by a *democratic* orientation policy would be determined through consultation with the individuals concerned, responsibility would be defined and assigned with the *consent* of those assuming it, authority would be delegated to implement assigned responsibility, and personnel would be selected to insure *mature assumption of responsibility* and the democratic administration[2] of policy at all levels.

A *paternalistic* form of top-level management combines aspects of both autocratic and democratic forms of administration. Paternalistic management can be likened to the "father" of a family who is deeply concerned with the welfare of the total family group, but who, because of his superior experience and wisdom, decides what is "best" for the family on the basis of *his* evaluation and interpretation of their needs rather than on the basis of their own estimate of their needs and wishes. If his interpretation coincides with theirs, as may well be the case, there is no conflict; but if the family differs from the father in their views as to what is "best" for them, serious conflict and rebellion may arise. Although responsibility may be assigned, authority for decisions rests ultimately with the father, and it is he rather than experience itself who rewards and punishes. Thus, learning how to please the "father" becomes more important than learning the *intrinsic consequences* of any kind of behavior. This places a premium on techniques of defense and ingratiation rather than on techniques of effective behavior. The process of selection of personnel in an organization with a paternalistic orientation will tend to favor those who are rather more dependent than independent, and who, because of this dependency, cannot feel secure without repeated signs of approval from the authority above.

Thus it can be seen that the process by which an organization develops is infinitely influenced by the peculiar cultural structures which become decernible; moreover, it becomes clear that these patterns are intimately related to the personalities which dominate the culture. As a matter of fact, an organization must be regarded as a miniature society with its own history, cultural developments, and social structure. The consequences of discrepancies between [verbal] goal definition and real [often unknown] goals are demonstrated in a management's failure to utilize fully the available talents, skills, and competencies of its personnel. They are also demonstrated in the failure to formulate specific company policies which would serve as decision-guides at lower echelons. They are further demonstrated in the inadequate communication of policies, resulting in ambiguity and confusion regarding specific aims at all levels.

The decision made on the basis of the planning steps must be carried out. *Execution* at the top level takes the form of delegation of both authority and responsibility. Obviously, it is impossible to define areas of such authority and responsibility where ambiguity predominates regarding a knowledge of what is to be accomplished by the assumption of responsibility. It is equally obvious that it is impossible to assume such responsibility without knowing what one is to be held responsible for. Moreover, it is axiomatic that it is impossible to assume responsibility, no matter how well defined it may be, without adequate authority to make and execute decisions within the defined area of responsibility.

These difficulties, then, are amplified, as it becomes necessary to distribute responsibility and authority to more and more subordinates to accomplish smaller and smaller tasks.

Consequences of such lack of definition are demonstrated in the insecurity of high-echelon executives, resulting in personal conflicts, breakdown of cooperative effort in execution, and in the overloading of top management with decision-making which should be an essential component of lower-echelon management.

The operations performed in the *execution* stage must be evaluated objectively. *Objectivity* is accomplished by formulating evaluative criteria in the planning stage. Any plan, no matter how carefully conceived and executed, will contain inefficiencies. It is important for the success of future operations that such inefficiencies be recognized, analyzed, and fed back into the total process, so that *future* planning and execution may profit from *past* errors.

Organization planning seldom employs such evaluative techniques. One reason for this may lie in the mistaken notion on the part of management that

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PROCESS ALLOWANCES FOR WORK STANDARDS

By Joseph S. Dwyer

Professor and Head, Department of Industrial Engineering and Engineering Drawing, Texas Technological College

One phase of establishing production standard which has been given very little attention in time study literature is the application of process allowances. Such phases of time study procedure as elemental breakdown, stop watch reading, performance rating, fatigue or rest allowances, etc., have received considerable attention, but the basis on which process allowances are established has been conspicuously avoided. Perhaps one reason for this neglect is that the practices adopted by a company for these allowances is more closely associated with wage incentive policy than the time study procedure. Although this may be true, the literature of wage incentives gives as little or less attention to the subject than does the time study literature. The unfortunate result is that no principles or procedures have been presented that can serve as a guide in establishing such allowances.

By process allowance is meant that allowance which is made in establishing a standard because of any characteristic of the operation which does not permit the operator a free or unrestricted opportunity to save time or increase production. The condition which creates the need for a process allowance is that production is not always a direct variable of the operator's ability to produce. As used here, a process allowance does not include such allowances that are frequently made for oiling the machine, grinding tools, adjusting the machine, etc. Nor does it include a blanket allowance, sometimes called an "incentive allowance," which is added to all elements. In its most common form, it is the allowance that is made for the machine elements of an operation and is frequently called the "machine allowance." This term is not wholly adequate in that similar allowances are needed for certain types of elements which are not machine elements.

From the time of Taylor it has been recognized that machine elements must be treated differently than the elements which are made up entirely of manual movements. Authorities on time study are in agreement that machine elements should receive different treatment than the manual elements. With but few exceptions, however, the authorities are very indefinite as to the treatment that should be given these elements. It would seem that the task of developing satisfactory procedures for the manual elements has focused the attention on these elements with the resulting neglect of other types of elements.

A falacy which seems to persist in time study circles is the inference that there are only these two general types of elements—manual and machine. Although this differentiation may include most of the elements encountered, this classification is not satisfactory when process allowances are considered for all possible situations. To illustrate this point, consider the following two situations:

(a) An operator does not have any manual work during the machining time, but is idle.

(b) An operator has been assigned manual work to perform during the machining time.

The difference between these two elements cannot be clearly established by using the dual classification, yet the difference is very important to determine a satisfactory process allowance. It is apparent that a more refined system of classification is needed to cover all types of relationships.

Before presenting a method of classification of elements, another confusing aspect of time study will be discussed as it has bearing on the use of the process allowance. The basic formula for setting a time standard is usually given in the following form or some variation:

Standard time (min.) = Selected time
+ selected time × performance allowance factor
+ rest or fatigue allowance (min.)
+ personal allowance (min.)
+ miscellaneous delay allowance (min.)
+ special allowances (min.) (oiling, grinding tools, interference, etc.)

This formula applies only to manual elements, and time study literature usually states or implies that a different formula is necessary for non-manual elements. A general form of this formula for non-manual elements is given as follows:

Standard time (min.) = Selected time
+ selected time × process allowances factor
+ rest or fatigue allowance (min.)
+ personal allowance (min.)
+ special allowances (min.)

The use of these two formulae is confusing in that this second formula is seldom specifically given in time study literature. Quite frequently it is presented only as an example in calculating the time standard for a machine element.

It will be noted that the only differences between these two formulae are the terms "performance allowance factor" and "process allowance factor." As used in either of the formula these factors would be expressed as a decimal. For example, if an operator is working with an effectiveness of 115%, the performance allowance would be 15% or .15 when used as a factor in the formula. If the operator's effectiveness is below normal, the factor would be negative.

To provide only one formula with which the standard for any type of element may be calculated, the two previous formulae can be combined into one expression:

Standard time (min.) = Selected time
+ selected time × performance allowance factor
+ selected time × process allowance factor
+ fatigue or rest allowance (min.)
+ personal allowance (min.)
+ miscellaneous delay allowance (min.)
+ special allowances (min.)

In this formula, as in the preceding ones, any of the allowances might have a value of zero depending on the characteristics of the element. Since this discussion is concerned only with the process allowance factor, the method of determining or applying the fatigue or rest allowance, personal allowance, miscellaneous delay allowance, and special allowances will not be considered, although they may have considerable influence on the selection of either the performance allowance factor or the process allowance factor. One important characteristic of this standard time formula is that if a performance allowance factor is used (such as for a wholly manual element) then the process allowance factor would be zero, and if a process allowance factor is used the performance allowance factor would be zero.

Elements of operations have certain characteristics which provide a means by which it is possible to classify the elements as to certain types for the pur-

pose of applying the process allowance.

Such elemental characteristics pertain to three different degrees or conditions. These are (1) the nature of the demands made on the operator, (2) the dependency of the elemental time on some factor other than the operator's ability or effort, and (3) the variability of the time required. Each of these conditions has an alternative which applies to any element. These are given as follows:

Condition		Alternative or Factor
Condition I	Pertains to the type of duty of the operator	Manipulation Idle (or attention required)
Condition II	Pertains to the dependency of the time on any other factor than the operator's ability or effort	Independent Dependent (or controlled)
Condition III	Pertains to the variability of the time required for the element	Variable limit Fixed Limit

Elements have other characteristics than the ones given and would be important for other considerations such as for stop watch observations, motion study, application of fatigue or rest allowances, etc. The purpose of the factors given above is to identify the nature of the element to permit the use of a satisfactory process allowance.

Any time study man will recognize that these three conditions apply to any element of an operation. Considering Condition I, an element consists of manipulative movements by the operator or he will be idle. By "idle" it is meant the absence of the need of body motions to perform the element. If the operator's attention is needed for observational purposes it is here considered the same as "idle." Because of the influence of the other two conditions some elements may consist of a combination of manipulation and idleness.

Condition II pertains to the dependency of the elemental time on any factor other than the operator's skill or effort. If the time required to perform the element should be controlled by the speed of a machine, then the element would be dependent. If any change in the operator's skill or effort changes the elemental time then the operation is independent of any exterior control. For example, the time required to walk 500 feet is independent because any variation in the time will be due to the operator. The time required to drive an automobile 500 feet is dependent on the speed of the automobile and not the skill or effort of the operator. The selection of this factor assumes that standardization of materials, equipment, method, etc. has been attained. To decide the factor that applies for Condition II, the following questions can be asked: "Will the time for the element vary with the operator's skill or effort?" If the answer is "yes" the factor "independent" applies, and if the answer is "no" it is a "dependent" or "controlled" element. When the element is "dependent" the thing that is imposing the control should of course be identified.

Condition II pertains to the variability of the time as imposed by the standardization of the method. For example: in a machining operation, the machining time will have a fixed limit if the feed is automatic. The elemental time will not vary appreciably from one cycle to the next.

It should be noted that Condition II is usually governed by Condition I, and Condition III is governed by Condition II. That is, if an element consists of manipulation it is apt to be independent,, and if it is independent it is apt to have a variable limit. There are exceptions to such patterns, however, and it is the exception that creates the need for a classification system.

Before considering specific examples for classification one other aspect or relationship must be considered. This pertains to the use of the term "element." By most definitions an element is an arbitrary subdivision of an operation selected for convenience of timing or for some other reason. An analyst is free to choose the ending of an element at any point that he desires. General rules are usually followed in making this decision, but such rules are not rigid or absolute, so it is left to the discretion of the analyst. Elements may vary depending on the timing device used, the skill of the observer, the length of cycle, etc. In some other cases a single motion such as "grasp" may be considered an element, and in other cases a whole series of motions may be considered an element. From this it is seen that the term "element" is very ambiguous. As used in this discussion the term has a very definite meaning and does not necessarity refer to the timed increment. Later in this discussion, six different types of elements are identified. As used here, an element corresponds to any one of these six time intervals. In making a time observation by using a stop watch or any other timing device, the timed increment could, and should be, more refined than the element considered in this discussion. In many cases the entire operation may correspond to a single elemental type in which a single process allowance would apply. In other cases the operation may be made up of several elemental types each requiring a different process allowance.

Of the three conditions previously listed, at least one factor of each condition will apply to the element. Elemental types are determined by the combination of these factors. There exist six different types each of which might require different treatment when incentives are used for operations including these various types. It is possible to have more types than these six by other combinations, but such combinations are not common.

The process allowance for each type is a matter of arbitrary decision. Any process allowance represents the policy of an individual company. These should established on the basis of what would be considered equitable payment of bonuses. For each of the elemental types, an allowance has been suggested. This is only the writer's opinion as to what would be a satisfactory and equitable allowance if all types of elements were to be encountered in a plant. Several factors, one of which is the predominance of one type of element, will affect the amount of the allowance. The various elemental types with examples will now be discussed relative to the process allowance for each.

TYPE I—Manipulation—Independent —Variable Limit

Example: A wholly manual operation such as an assembly operation.

This is one of the most common encountered in the performnace of work. Assuming that standardization of method, materials, etc. has been attained, the time required is dependent on the effectiveness of the operator and there is no fixed limit imposed on the operation. Most incentive plans and time study procedures are designed for operations made up of this type of element because the most satisfactory results of the use of incentives is obtained when applied to operations of this type.

For elements of this type a performance allowance is necessary to adjust for the effectiveness of the operator. The process allowance factor would be zero, therefore the process allowance in the equation drops out.

TYPE II—Manipulation—Dependent —Fixed Limit

Example: Machine element with power feed and a full internal work assignment for the operator.

TYPE III—Manipulation and Idle— Dependent—Fixed Limit

Example: Machine element with power feed and less than a full internal work assignment for the operator.

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THE ENGINEER—HIS OWN PRESS AGENT

By Francis C. Smith
Editor of Southern Power and Industry, Atlanta, Georgia

Many potentially great engineers have remained obscure because they chose an isolationistic attitude. Very few people rise above mediocracy without cultivating and securing the friendly cooperation of others. No one can accomplish very much as a solo worker—you need greater leverage for your ideas. And that leverage comes from persuading others to put *their* shoulder to *your* wheel.

Returns to the Author

Articles and reports are like telephones; they can go right through doors that are ordinarily closed to you. Walls and distance fail to stop the flow of knowledge.

Good reports, good letters, and good articles tend to eliminate sloppy thinking. Ideas expressed verbally, on the spur of the moment, cannot possibly convey the clear, complete understanding that is set forth in carefully prepared business reports and memorandums. From good report writing on your job, it is just a short jump to technical article writing—but look at the increase in leverage.

Reports are passed along from your Supervisor to his Department Manager, and frequently on up to the President, and your name rides with them. Your articles go still further—to other towns, other states. They are quoted, abstracted, and discussed.

Soon someone that counts starts asking, "Who is this man, that did such a good job for the Doaks Manufacturing Company on developing new timesaving production handling procedures?" He begins to get letters, people ask him questions; he becomes an "authority." That's no joke, it works just that way. Let me give you a few examples.

The Training Supervisor of a Southern Company furnished us an excellent article showing exactly how their training program works. Soon I got a letter from the Industrial Relations Department of one of the largest engineering firms in the nation.

> "Your March isue contains a description of one of the finest supervisory conference programs it has been our privilege to see. We are very anxious to send reprints of this article to the presidents of our client companies in the utility industry.
>
> "Will you kindly send us seventy-five (75) reprints of the article so that this program can be called to the attention of our people."

It certainly will not do the author any harm to have that big engineering firm send his article to top executives of major utility companies.

Here's another case: An engineer with a large firm in Georgia furnished us a good article on some technical phase of their operations. A recent letter from the author says the article reached the instructors in their Texas branch. They complimented him on the article and asked permission to use it in their instruction. That is particularly good, because the top men in his company strongly favor such activity.

And going back a little further—there is a letter in my file that gives two articles in our publication full credit for advancing the author from Superintendent of one small plant to Manager of Production for one of the South's largest companies. No, it was not quite that simple, the President didn't just see his article and push him to the top. There were a couple of steps in between, but the whole change took place within a year.

A slightly different angle is illustrated by an experience with an executive with one of the large oil companies in Texas. He didn't care too much about additional fame or money, but he wrote a technical article for me just because he is friendly with me and wanted to be accommodating. His article reached unusually high interest, and he received letters from many famous engineers in America and from several countries in Europe. He says "it was a source of great annoyance," but I notice I still get a particularly cordial reception when I go to his office—or for that matter, whenever I call on any of his men.

I believe those few instances illustrate very well what can happen *when the engineer becomes his own press agent*. But there are other worthwhile considerations.

There's a lot of satisfaction in seeing your ideas put to work in a broader field. Leadership is always gratifying, and the writers are the leaders. Or maybe we should say the leaders do the writing—it's hard to be sure. But anyway think it over. How many famous engineers do you know that have not done a great deal of technical writing?

Another point often overlooked is that you don't know your own mind until you put your thoughts in writing. Writing breeds clear thinking. Many basic improvements owe their birth to clearer understanding developed as the inventor or developer tried to put his ideas on paper.

Returns to Your Employer

Most of what I have already said concerns benefits to the individual engineer. But an engineer's writings seldom involve him alone. His associates and his employer also profit from his efforts.

Great benefits are derived from the exchange of ideas among engineers in related fields. The success of trade associations and professional societies is determined almost entirely by the willingness of individual members to aid each other in the solution of mutual problems. The same is true of technical writing, but on a larger scale. The writer of a good technical article almost invariably receives comments from the field that help to complete and improve the plan he described. And more important still, he is frequently astounded to receive information showing that an entirely new solution deserves his consideration. The man that gives aid to others is most likely to receive help when he needs it. Thus the company receives direct benefit from its engineers' papers, in way of improved plant performance.

Good publicity invariably brings improved public relations and employee relations—and there is no better publicity than the telling of accomplishments and improvements in well prepared technical articles. Some companies that spend big money on publicity fail to recognize these facts—others capitalize on their employee's writing to great advantage.

A liberal company policy or school policy on employee writing goes far toward helping hold good men. Active men like to tell what they are doing and too tight a rein tends to encourage taking their talents where they are appreciated.

Certainly an employer has the right to check and approve articles then mention the company or institution name, but the mechanics of such checking should be simple and a young engineer should not be forced to submit his articles to a straight-laced, superconservative for approval. Every institution that is doing anything worth writing about should have a wide awake publicity head available for checking and approving such material for publication.

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CRITERIA FOR EVALUATING THE UTILITY OF MECHANICAL PRODUCTION TOOLS

By Robert Eastman
Associate Professor, School of Industrial Engineering, Georgia Institute of Technology

Georgia Institute of Technology is one of seven technological information centers in the U. S. serving European industrialists under the Mutual Security Agency's Technical Assistance Program, and in particular its Technical Question and Answer Service. Encouragement of technical productivity in Europe is the aim of the program.

Sixteen Mutual Aid countries take part, including Great Britain, Norway, Belgium, Netherlands, France, Germany, Austria, Denmark, Greece, Turkey, and Italy.

Say an Italian helmet manufacturer wants to supply the Atlantic Army with plastic liners for steel helmets but lacks "know-how." Mr. Helmet Maker sends a query to his Italian information center (called a Productivity Center) . . . what about raw materials? Types of presses needed? And so forth.

The Italian Productivity Center screens the query. If it cannot be satisfactorily answered in Europe, it is translated and relayed across the Atlantic to the Department of Commerce, Office of Technical Services (OTS), Washington, D. C.

One of following seven information centers will receive the question: Georgia Tech; Armour Research Foundation, Chicago, Ill.; the Crerar Library, Chicago; Pennsylvania State College, State College, Penna.; Arthur D. Little, Inc., Cambridge, Mass.; Stanford Research Institute, Stanford, California; or Battelle Research Institute, Columbus, Ohio.

At Georgia Tech, John Lane, director of research information service, has three possible "contacts" at hand: The staff, which includes hundreds of scientists and administrative personnel; a manufacturer; the literature, or all three.

So far Georgia Tech has handled more than 150 European technological questions during its twenty-one months participation in the program, and the pace is picking up.

Many seek to improve their product-textile machinery, ceramics, and lubricants are examples.

Of course, trade secrets are not revealed. A manufacturer of book matches would not reveal how he makes his machinery. He would disclose, however, that a stapling machine is used to attach the matches to covers.

Americans can get the same type of information from the Department of Commerce, Office of Technical Services, Washington 25, D. C.

The basic principle of productivity-raising tools is, of course, to increase the effectiveness of human effort. This can be done, to some extent, by using tools which supplement the effort of the worker with mechanical power, which increase his accuracy or which substitute machine operations for manual ones. Use of productivity tools normally calls for less effort from the worker, yet it enables him to increase his production.

It seems necessary to use several different criteria to evaluate a given mechanical device as a tool. It is suggested that three separate criteria be used, the first to establish that the device is an aid to productivity, the second to eliminate some items which are not really tools and the third to establish the relative values of different tools. Needless to state, it will be necessary to establish certain minima or maxima for some of the criteria before they will be useful.

Basic Qualifications

To qualify as a productivity tool, it is recommended that a device meet one or more of the following criteria:

1. Performs an operation faster;
2. Handles larger work units with the same or less effort;
3. Eliminates one or more operations;
4. Eliminates one or more job elements;
5. Reduces or eliminates waste motion;
6. Decreases the accident hazard;
7. Reduces the operator's fatigue;
8. Performs an otherwise impossible operation;
9. Reduces the amount of scrap or rework;
10. Allows cheaper material or supplies;
11. Produces a superior product without added expense.

Each of these criteria will now be discussed.

(1) The first criterion, performing an operation faster, probably applies to more tools than any other. It covers items used by many industries from building construction to textile manufacturing. For example, spray painting is faster than brush painting. An automatic thread tier has been developed for the textile industry. Air and electric tighteners are used for rapid assembly of parts held by nuts and bolts. An automatic nailer has been developed for shoe manufacturers and wood products manufacturers.

(2) Amplification of the force exerted by the worker is one of the most fruitful sources of increased productivity. Handling of material (which in the United States absorbs one-fifth or more of all labor cost) is greatly expedited by the use of power tools. With a simple chain hoist or a motor hoist one worker can lift objects which would otherwise strain the capacities of several laborers. A pneumatic hammer can strike with a greater force than a worker using any type of hand hammer. Many of these devices also perform the operation faster. An additional saving usually comes from a decrease in damaged goods.

(3) Eliminating an operation is usually done by changing the design or specification of the part or by simplifying the job. Self-tapping screws have been developed which eliminate the time-consuming tapping operation. Pre-positioned carbon paper eliminates individually placing the carbon between the sheets of paper.

(4) The elimination of job elements is a prolific source of savings on repetitive operations. Hoppers and chutes can be designed to pre-position material to eliminate the elements of human positioning of the work. Multipurpose tools can sometimes be used, thus avoiding unnecessary reaches.

(5) Productivity can be improved by reducing waste motion even though the number of operations and job elements remain the same. For example, an air operation or electrically operated screwdriver may be counter balanced and hung close to the work place. It can be reached with a short motion, yet moves out of the way when not needed. The Dvorak-Oealy simplified typewriter keyboard greatly increases the output of typists by reducing waste finger motion. The most commonly used letters appear on the home row and finger movements are at a minimum. Many of Henry Ford's great improvements in output came from reducing walking time and reaching time.

(6) At first glance, decreasing the accident hazard seems to bear little relation to increasing productivity. However, the direct and hidden costs of accidents are considerable. Moreover, investigation has well established that unsafe tools and equipment reduce production by causing excessive tension, fatigue, and by introducing hesitations into the work cycle. Dial feeding of punch presses has increased production greatly; however, part of the increase is due to elimination of waste motion.

(7) Reduction in worker fatigue is usually a by-product of a tool primarily developed to meet one of the other criteria. However, the lessened fatigue does reduce the amount of rest time

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Conference on "Industrial Engineering in Labor Relations"

Thursday, April 30 and Friday, May 1, 1953

HOTEL NETHERLAND PLAZA, CINCINNATI, OHIO

S. H. RASKIN, General Conference Chairman

Conference Program: Thursday, April 30

CHAIRMAN: DR. ROBERT N. LEHRER, Associate Professor of Industrial Engineering, Georgia Institute of Technology. Ph.D. at Purdue University. Registered Professional Engineer. Associate Editor of the *Journal of Industrial Engineering*, Consultant in Industrial Engineering and author of numerous articles in professional and trade journals.

8:30 A. M.—REGISTRATION, fourth floor, Netherland Plaza.

9:00 A. M.—WELCOME AND INTRODUCTION TO PROCEEDINGS, Dr. Robert N. Lehrer.

9:10 A. M.—SETTING PRODUCTION STANDARDS: *A technical discussion of the setting of accurate standards in industry.*
Speaker: DR. HAROLD O. DAVIDSON, Assistant Professor of Industrial Engineering at Ohio State University. Ph.D at Ohio State University. Author of *Functions and Bases of Time Standards.*

10:40 A. M.—JOB EVALUATION: *An analysis of the subject and its effect upon labor relations.*
Speaker: A. W. ISENHART, Vice-president in Charge of Personnel, Dayton Power and Light Company. Past President of Personnel Association of Dayton and for thirty-six years has been active in the field of personnel and human relations.

12:00 Noon—LUNCHEON, Pavilion Caprice, Netherland Plaza.
Address: *What Management Expects from the Industrial Engineer.*
Speaker: HOMER E. LUNKEN, vice-president and Assistant General Manager, the Lunkenheimer Company, Cincinnati, Ohio. President of Cincinnati Chapter, S.A.M. Recently presented "Human Research Findings in Employee Productivity" before AMA personnel conference.

2:00 P. M.—SELLING INCENTIVES TO LABOR: *A discussion of the value to the individual worker of incentives and allied subjects.*
Speaker: DR. LEONARD R. SAYLES, Assistant Professor, School of Industrial and Labor Relations, Cornell University. Ph.D in Industrial Economics, Massachusetts Institute of Technology and co-author of *The Local Union—Its Place in the Industrial Plant.*

3:30 P. M.—EFFECTS OF STANDARD DATA SYSTEMS ON LABOR RELATIONS: *A discussion of the effect upon the worker created from the use of the various standard data systems.*
Speaker: JOHN L. SCHWAB, John L. Schwab and Associates. National Director and Chairman of the 1948 National Conference of the *Society for the Advancement of Management.* Co-author of *Methods—Time Measurement.*

Conference Program: Friday, May 1

CHAIRMAN: J. NOBLE BRADEN, Executive Vice-President of the American Arbitration Association. Has been an officer of the American Arbitration Association since its inception. On staff of Graduate School of Business Administration, New York University. Author of *Code of Arbitration* and co-author *Practice of Commercial Arbitration.*

9:00 A. M.—NEGOTIATION STANDARDS: *The industrial relations-industrial relations team in contract negotiations.*
Speaker: PAUL W. DEUBERY, Director of Industrial Relations, Crosley Division AVCQ, Cincinnati, Ohio. Formerly Personnel Director of Truscon Steel Company and National Tool Company.

10:30 A. M.—HANDLING GRIEVANCES: *The Industrial Engineer's role in the handling and prevention of grievances.*
Speaker: ROBERT RAULSTON, Director of Labor Relations, Aluminum Industries, Cincinnati, Ohio. Formerly General Organizer and Regional Director, Upholsterers' International Union; and Assistant Industrial Relations Director, Clopay Corporation.

12:00 Noon—LUNCHEON, Pavilion Caprice, Netherland Plaza.
Address: *A Union Looks to Industrial Engineers.*
Speaker: WILLIAM GOMBERG, Chief Industrial Engineer, International Ladies' Garment Workers' Union, Ph.D Columbia University, and author of many articles including the *Relationship Between the Union and the Engineer.*

2:00 P. M.—PREPARING FOR ARBITRATION: *The technicalities of arbitration and the advisory function of the engineer.*
Speaker: J. NOBLE BRADEN.

3:30 P. M.—MEDIATION AND CONCILIATION: *A discussion of mediation and conciliation services and their place in industry.*
Speaker: WALTER A. MAGGIOLO, General Counsel and Assistant to Director, Federal Mediation and Conciliation Service. Received Crusader Award, Holy Cross College, for outstanding contributions to education in labor relations.

Conference Fees

	Member	Non-Member
Two-day Conference, Luncheon	$25.00	$30.00
Thursday Conference, Luncheon	15.00	17.00
Friday Conference, Luncheon	15.00	17.00

...trial Engineers Fourth Annual

National Convention

Friday, May 1 and Saturday, May 2, 1953

HOTEL NETHERLAND PLAZA, CINCINNATI, OHIO

S. H. RASKIN, General Committee Chairman

Convention Program: Friday, May 1

6:00 P. M.—REGISTRATION, fourth floor, Netherland Plaza Hotel.
6:30 P. M.—BOARD OF TRUSTEES DINNER, Parlors A, B, C, D, Netherland Plaza Hotel.
7:30 P. M.—BOARD OF TRUSTEES MEETING, Parlors A, B, C, and D, Netherland Plaza.
MATTHEW A. PAYNE, Presiding.
7:30 P. M.—MEETING OF NATIONAL COMMITTEE HEADS, Convention Headquarters, fourth floor, Netherland Plaza Hotel.

Convention Program: Saturday, May 2

8:30 A. M—REGISTRATION, fourth floor, Netherland Plaza Hotel.
9:00 A. M.—KEYNOTE ADDRESS: *Industrial Engineering in Labor Relations.*
Speaker: DR. LILLIAN M. GILBRETH, Consulting Engineer, President of Gilbreth, Inc., Montclair, New Jersey, Ph.D Brown University; Dr. Engrng., Rutgers College; Sc.D. Russel Sage College; LL.D. University of California; L.L.D. Smith College. Professor of Management, Purdue University; and, together with husband, Frank B., founder of the Science of Motion Study. FELLOW or A.I.I.E.
10:30 A. M.—SIMPLIFYING INDUSTRIAL ENGINEERING WORK.
Speaker: CHARLES WINKELMAN, Director of Industrial Engineering, Gardner Board and Carton Company, Middletown, Ohio. Formerly Industrial Engineer with Belden Manufacturing Company for twenty-nine years. Lectured at Purdue University, and recently has been lecturing over entire country on Industrial Engineering subjects.
12:00 Noon—LUNCHEON, Hall of Mirrors, Netherland Plaza Hotel.
WELCOME AND INTRODUCTION, Hon. Carl W. Rich, Mayor of Cincinnati.
Address: LABOR LEGISLATION: *The Trends of Federal Labor Legislation.*
Speaker: J. MACK SWIGERT, Partner in law firm of Taft, Stettinius, and Hollister, Cincinnati, Ohio. Graduate of Harvard Law School. Gave assistance to Senator Taft at the time the Taft-Hartey Law was drafted. Author of numerous articles on labor law and collective bargaining.
2:00 P. M.—A.I.I.E. BUSINESS MEETING
MATTHEW A. PAYNE, *presiding*
6:30 P. M.—INSTALLATION OF OFFICERS BANQUET.

Officers

MATTHEW A. PAYNE, *President*
RAYMOND VILLERS, *Vice-President*
CARL B. AVERY, *Vice-President*
FRANK F. GROSECLOSE, *Vice-President*
H. G. THUESEN, *Vice-President*
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Convention Fees

	Member	Non-Member
Convention, Sat. Only, Luncheon	$ 8.00	$10.00
Installations Banquet Saturday (not including above)	3.00	
Board of Trustees Dinner, Friday	4.00	
Conference and Convention, (including all Luncheons)	30.00	36.00

GRAPHICAL DETERMINATION OF WORK LOADS FOR MULTIPLE MACHINE ASSIGNMENTS

By Dale Jones, Associate Editor

The determination of operator work loads in multiple machine assignments where machine interference prevails is one of the more common "rule-of-thumb" management procedures. Difficulties in arriving at scientific solutions to the problem can be attributed to general absence of interference estimation tools and inaccessibility of relevant cost information. However, even when this information is available, work load planners are usually reluctant to utilize formulae.

This article describes two applied work load determination techniques. These techniques have met the favor of planners because they involve simple graphics rather than formulae. The tools to be described apply to two common types of multiple machine assignment: (1) assignments where one operator services a limited number of machines having running cycles which can be so coordinated as to warrant a planned or fixed servicing pattern designed to minimize machine interference and (2) assignments where one operator randomly services several machines having production cycles which cannot be coordinated.

Machine interference is the idleness a machine experiences when it is nonproductive, waiting to be serviced by its operator who is servicing some other machine in the assignment. Approximately one-half of the inefficiency of machines tended in multiple can be attributed to machine interference, the remaining efficiency being due to regular down-time servicing. In view of the expense caused by machine interference, in the form of lost profit, the economic significance of this form of inefficiency is apparent.

Consider a weave room where a weaver is assigned ten looms and 90% work load. Matching 10 machines with 90 in the accompanying Table I gives 7.9% average idleness per machine due to machine interference. Now, whether this is more or less than the most economic amount of interference idleness depends principally on the profit being earned on the cloth and the average hourly earnings of the weavers. By adding weavers and reducing the work loads the 7.9% interference can be reduced and more cloth can be shipped—bringing in more sales dollars. On the other hand, by increasing the work loads of the weavers the payroll expense can be reduced but the increased interference will cause sales income to drop. Because of the inter-relationships between interference, operator idleness and ever-changing profit, it is apparent that the optimum degree of interference in one type of activity may well be significant by different from that of another activity—and, for a given activity, the optimum amount of interference this spring may be significantly different from that for next fall.

In order to achieve the most economic balance between machine idleness due to interference and operator idleness due to work load limitations, the planner of multiple machine assignments must ask and be able to answer the following questions in behalf of each operator:

1. What are the available work assignment alternatives for this operator?
2. Which of these possibilities, if assigned to this operator, should result in the least total expense due to machine interference idleness and operator idleness due to work load limitations?

The answer to the first of the foregoing questions is generally immediately obtainable in the planning department. Cost information integrated with graphic tools such as those to be described permit the answering of the second question.

Assignments With Planned Servicing Sequence

Figure 1 illustrates an assignment of three semi-automatic machines tended by one operator. This is a typical assignment in a department of 300 machines, all performing the same basic operation. The first graphical work load determination method to be described was developed to accommodate assignments of this type. An average of 80 operators are employed in the department on each of three shifts. The machines are arranged closely together, there being approximately three feet between adjacent machines. There are no restrictions as to the number of machines which can be assigned to one operator: in practice, the number varies from 2 to 5, inclusive. The machines are randomly located from the standpoint of machine size. The lengths of production run vary considerably from machine to machine, the average being approximately fifteen shifts (or five days).

The shaded portion of any given machine cycle in Figure 1 represents machine down time involving unloading, loading and starting the machine. The space between the right side of any shaded block and the upward right angle bend of the line extending to the right represents automatic time over which the operator has no control. Notice, in Figure 1, that while the operator services Machine No. 1, Machine No. 2 experiences machine interference. Then, as the operator services Machine No. 2, Machine No. 3 experiences machine interference. Also note that the operator is unavoidably idle due to work load limitations after completing the servicing of Machine No. 3, since he must wait for completion of the automatic time of Machine 1. As can be seen in Figure 1, the interference idleness of any machine per battery cycle is the difference between its cycle time and the battery cycle time. In the more complicated cases, where a machine is serviced more than once per battery cycle, the machine's interference idleness is the difference between the total of that machine's cycle times per battery cycle and the battery cycle time. Also, as can be seen in Figure 1, the operator's unavoidable idle time per battery cycle is the difference between the battery cycle time and the total of his servicing time during the battery cycle. In those assignments where the operator's total servicing time per battery cycle equals or exceeds the longest machine cycle time, the operator is over-assigned and has no idleness.

The assignment illustrated in Figure 1 may or may not represent the most economic utilization of the operator and machines, in light of the alternatives at hand. If, for example, it were possible to assign to the operator, products requiring the same cycle time and total servicing requirements equal to this common cycle time, both machine interference and operator enforced idleness would be eliminated. In practice, these ideal conditions are seldom attainable in the department under consideration: it is seldom that as many as two of the 300 machines are producing the same product—and the cycle times of the products vary considerably. In fact, many assignments involve products with cycle times so different as to warrant the operator servicing the machines different numbers of times per battery cycle rather than once each battery cycle as illustrated

in Figure 1.

Whenever a production run is near completion on a given machine the work load planner studies the cycle times and the operator servicing times of the production orders in hand to determine which alternatives should be considered for inclusion in the assignment when the pending order completion occurs. The planners' objective should be to effectuate assignments involving the least total machine interference and operator idleness expense. These expenses may be defined as follows (discussions in support of these definitions appear later in the article):

The hourly expense due to machine interference idleness, as applied to any given machine in any given assignment is the difference between the sales income and variable production, handling and selling cost of the production which could otherwise have been realized from the lost capacity due to the interference during the hour. Only that overhead which varies directly with production and only the "applied" labor cost of the operator (not the expense of enforced idleness) should be included in the "variable production, handling and selling cost" mentioned above.

The hourly expense due to operator unavoidable idle time, as applied to any given assignment is the hourly rate of pay granted to the operator for unavoidable idle time multiplied by the portion of the hour the unavoidable idleness is incurred.

In the department under consideration, the average hourly machine interference idleness expense at the time of this writing, by machine size, is as follows: Sizes 3" and 5" = $2.20; Sizes 6" and 8" = $2.80; Sizes 10" and 12" = $3.30; Sizes 15" and 17" = $5.00. The average hourly pay rate for operator unavoidable idle time due to work load limitations is $1.70.

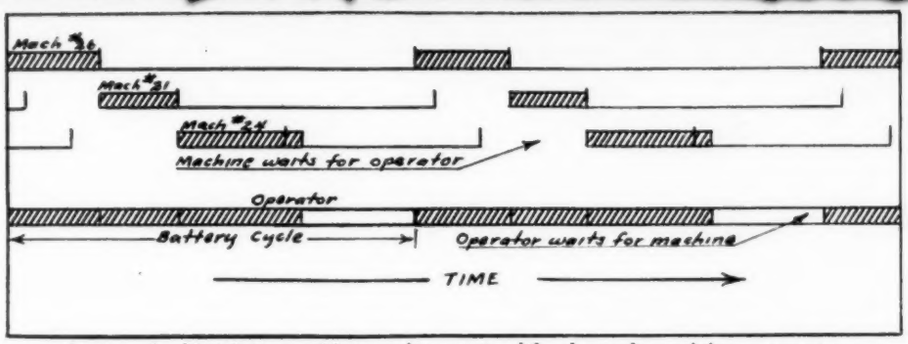

Figure 1. Multiple machine assignment with planned servicing sequence.

As was previously pointed out, work load planners are generally reluctant to use formulae which properly treat work load idleness expense determinants. Moreover, the use of such formulae often proves abnormally time consuming. Accordingly, the form illustrates in Figure 2, which graphically accommodates the work load idleness expense determinants, was designed to permit planners to select optimum work load alternatives.

Figure 2 illustrates the idleness costing of the assignment illustrated in Figure 1. The costing is accomplished as follows:

The cycles of the machines in the assignment under consideration are symbolized in the upper horizontal rows.

The operator's servicing duties are shaded in the bottom horizontal row.

The battery cycle time is determined. In assignments where it is best to service each machine once per battery cycle, such as that illustrated, the battery cycle time is the time of longest of the individual machine cycles or the total of servicing times per battery cycle, whichever is the longer. In the case illustrated the battery cycle time is 5.25 minutes.

The battery cycle time, as recorded graphically on the operator's battery cycle scale (the bottom row), is connected, with a straight line, with the reference point at the top of the card.

The idleness expense of any given machine is determined by projecting vertically from the end of the machine's cycle to the diagonal line, then horizontally to the left to the Hourly Idleness Expense curve for machines of that size, then vertically downward to the Hourly Idleness Expense. The same procedure is followed when determining the opera-

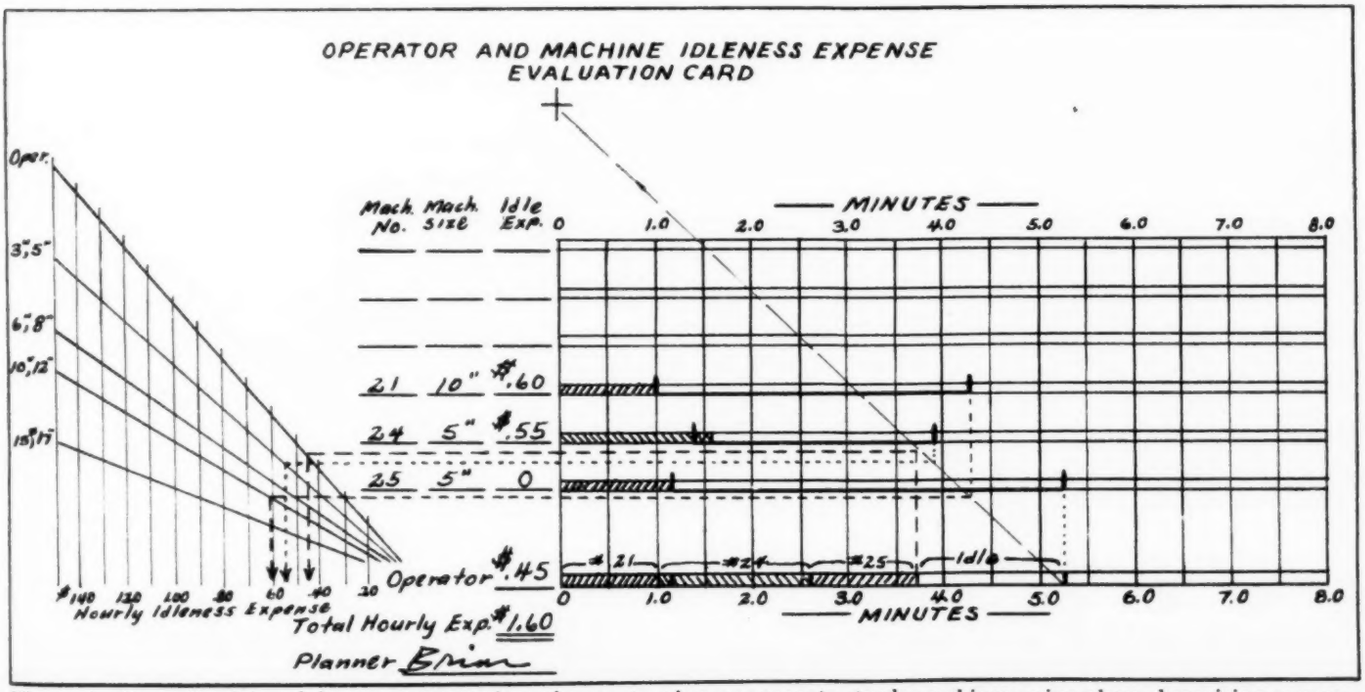

Figure 2. Form for determining most economic assignments when one operator tends machines, using planned servicing sequence.

tor's hourly idle expense, with the exceptions that the right end of the operator's shaded servicing is projected to the diagonal line and then horizontally to the operator's Hourly Idleness Expense Curve.

The idleness expense values are recorded and totaled as illustrated and then the planner signs his signature.

The foregoing procedure is followed for alternate assignment possibilities until that involving least operator plus machine idleness cost is found. In practice, since the curves illustrated in Figure 2 require revision in accordance with expense change, they are not a part of the illustrated "Operator and Machine Idleness Expense Evaluation Card." Instead, the curves appear on a lucite jig into which the cards are inserted, permitting rapid pricing as well as easy revision of the curves.

Each Operator and Machine Idleness Expense Evaluation Card representing an assignment is a record of the efforts of some planner. The effectiveness of these efforts is, to a large extent, reported in the Total Hourly Expense space of the card in Figure 2. In those cases where special demands preclude the possibility of assigning a most economic alternative, a note mentioning the reason for the resultant excessive Total Hourly Expense is written in the space provided at the bottom of the card.

The practical limitations of the work load determination procedure illustrated in Figue 2 will be discussed later in this article. At this point, however, it will be helpful to summarize, to insure an understanding of what has been said and what is to follow. There are two expenses relevant to the problem of determining optimum work loads: machine interference idleness expense in the form of lost profit and operator idleness expense in the form of wages paid for enforced waiting time due to work load limitations.

The optimum operator work load is that alternative which involves the least total of these expenses. When servicing and automatic times are known, and when a fixed servicing sequence can be planned and followed, it is possible to accurately predict interference idleness for individual machines and the operator's idleness due to work load limitations. Thus, accurate cost and sales figures integrated with a plan for varying the multiple machine assignment labor force in accordance with economics needs (which doesn't necessarily mean "hiring and firing"), permits accurate realistic pricing of this idleness via the technique illustrated in Figure 2.

The operator servicing demands in multiple machine assignments such as those involved in weaving, box making, gear hobbing, automatic screw machine production, cartoning, etc., are generally so random and variable that a fixed servicing sequence is not possible or is not economically warranted. Accordingly, a work load determination method which assumes a fixed servicing sequence, such as that described in Figure 2 is invalid for these conditions.

Assignments With Random Servicing

Figure 3 is a recently developed tool for determining the most economic work loads to assign to operators of multiple machine assignments involving random servicing demands. The technique is basically the same as that illustrated in Figure 2 in that it pits machine interference profit loss against the expense of idle operators. However, it differs from Figure 2 in the manner in which machine interference time and operator enforced idleness time is evaluated. The use of Figure 3 will be described in detail following a discussion of the development of its foundation: Tables I and III.

A method of evaluating random machine interference in multiple machine assignments tended by one operator was presented in the article "Machine Interference," in this publication, September, 1949. This article described in detail the development of a family of interference curves, and the "interference computer" which was developed to test the validity of the curves. Because of the close agreement between the theoretical interference value, the interference computer test results and many checks made by practicing engineers, the curves have been converted to tabular form, illustrated in the accompanying Table I.

The application of Table I can be illustrated by a simple example. Assume one operator is to tend 20 looms, each of which require an average of one minute operator servicing (including walking) per 18 minutes automatic running time. The work load per loom on an individual attention basis is therefore $1 \div (1+17)$ or 5.26% and the Total Work Load on Individual Attention basis is $20 \times 5.26\%$ or 105%. Now, matching 105 with 20 machines in Table I gives 9.3% average interference idleness per loom. That is, on an average, each loom will be idle approximately 9.3% of overall time due to machine interference for these conditions.

The application of Table III, which is based on the formula Operator's Unavoidable Idle Time = (100% — Total Work Load on Individual Attention Basis) $\times$ [(100% —% interference) $\div$ 100], can be illustrated by using the above assumptions. To evaluate the operator's unavoidable idle time percentage when tending the looms described above it is necessary only to match 105 with 20 machines in Table III, giving 4% operator idle time. That is, the operator will be unavoidably idle approximately 4% of overall time for the assumed conditions. Of course if the operator has incidental necessary duties which can be performed when all machines are producing, the percent of time spent on same should be deducted from the value determined from Table III. In summary, the foregoing assumed assignment will entail the following efficiencies, according to Tables I and III:

(1) Approximately 9.3% of the available production time of each of 20 looms will be lost due to interference. This represents the production loss of $20 \times .118 = 2.36$ equivalent

TABLE I
AVERAGE PERCENTAGE INTERFERENCE PER MACHINE VERSUS TOTAL PERCENTAGE WORK LOAD OF ASSIGNED MACHINES

No. Machs.	Operator's Total Percentage Word Load* on Individual Attention Basis														
	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
4	3.2	4.0	4.8	5.8	6.9	8.0	9.4	10.9	12.5	14.1	15.9	17.9	19.8	21.7	23.7
5	2.8	3.5	4.2	5.1	6.1	7.2	8.5	9.9	11.4	13.0	14.8	16.7	18.6	20.5	22.6
6	2.5	3.1	3.7	4.5	5.5	6.5	7.8	9.0	10.5	12.1	13.7	15.7	17.7	19.6	21.7
7	2.2	2.7	3.3	4.1	5.0	6.0	7.1	8.3	9.7	11.3	13.0	14.8	16.8	18.8	20.9
8	1.9	2.4	3.0	3.7	4.5	5.5	6.5	7.7	9.0	10.6	12.2	14.0	16.0	18.2	20.2
9	1.7	2.2	2.8	3.4	4.2	5.1	6.0	7.2	8.4	9.9	11.5	13.4	15.4	17.6	19.7
10	1.5	2.0	2.6	3.2	3.9	4.7	5.6	6.7	7.9	9.4	10.9	12.9	14.9	17.1	19.4
11	1.4	1.9	2.4	3.0	3.7	4.4	5.3	6.3	7.5	8.9	10.5	12.4	14.4	16.7	19.0
12	1.3	1.8	2.2	2.8	3.5	4.1	5.0	5.9	7.1	8.5	10.1	12.0	14.0	16.3	18.6
13	1.3	1.7	2.1	2.6	3.2	3.9	4.7	5.6	6.8	8.1	9.7	11.6	13.6	16.0	18.3
14	1.2	1.6	2.0	2.4	3.0	3.7	4.4	5.3	6.4	7.7	9.3	11.2	13.3	15.7	18.0
15	1.2	1.5	1.9	2.2	2.8	3.5	4.2	5.1	6.1	7.4	8.9	10.8	13.0	15.4	17.8
16	1.1	1.4	1.8	2.1	2.7	3.3	4.0	4.8	5.9	7.0	8.5	10.5	12.7	15.0	17.6
17	1.1	1.3	1.7	2.0	2.5	3.1	3.8	4.6	5.6	6.7	8.2	10.2	12.4	14.8	17.4
18	1.0	1.2	1.6	1.9	2.4	3.0	3.6	4.4	5.4	6.5	7.9	9.9	12.2	14.7	17.3
19	1.0	1.1	1.5	1.9	2.3	2.9	3.5	4.2	5.2	6.2	7.7	9.6	12.0	14.6	17.2
20	.9	1.1	1.4	1.8	2.2	2.8	3.4	4.1	5.0	6.0	7.5	9.3	11.8	14.5	17.1
25	.8	.9	1.2	1.5	1.8	2.3	2.8	3.4	4.2	5.2	6.6	8.4	10.8	13.7	16.9
30	.7	.8	1.0	1.2	1.6	2.0	2.4	2.9	3.7	4.6	5.9	7.7	10.2	13.3	16.8
40	.5	.6	.8	1.0	1.2	1.5	1.8	2.3	2.9	3.7	5.0	6.8	9.4	13.2	16.6
50	.3	.5	.6	.8	.9	1.2	1.5	2.0	2.5	3.2	4.2	6.1	9.3	13.2	16.6
75	.2	.3	.4	.5	.6	.8	1.0	1.3	1.7	2.2	3.3	5.2	9.1	13.1	16.5
100	.2	.2	.3	.4	.5	.7	.9	1.1	1.5	1.9	2.8	5.1	9.0	13.0	16.5

*Figure the work load at incentive pace and exclude deferable "internal" duties (those which can be performed when all machines are producing).

fully productive (no interference) looms.

(2) The operator will be idle approximately 4% of the time he tends this assignment.

If the operator should tend only 16 of the above mentioned looms, giving a total work load on an individual attention basis of only 84%, the equivalent non-productive looms due to interference would be only approximately .85 but the operator's percentage unavoidable idle time would be 19%. Now, which of the above alternatives represents the most economic combined utilization of men and machines? The answer to this question calls for a knowledge of the relevant cost factors:

(1) Margin between variable cost (includes costs of material, applied labor, variable manufacturing overhead, packing and shipping costs and sales commissions) and sales income, for one hour's production from one machine (loom) assuming no interference;

(2) Hourly pay rate for operator unavoidable time.

In order to illustrate the basis of Figure 3, let us further assume, in behalf of the foregoing conditions, a "margin" of $0.40 per hour and an $1.60 hourly pay rate for operator unavoidable time. Pricing the expense of machine and operator idleness in the foregoing alternative involving 20 looms and 105% work load we get (2.36×$0.40) + (.04×$1.60) or $1.00 idleness expense per hour. For the second alternative calling for an 84% work load on 16 looms we get (.85×$0.40) + (.19×$1.60) or $0.65 idleness expense per hour. Now, if the alternatives under consideration are in a department employing a sufficient number of multiple machine assignment operators to permit frequent variation of the total effort assigned to multiple machine assignments, the economy in alternative 2 as compared with alternative 1 can be realistic.

Referring to Figure, 3, it can be seen that the ratio of hourly "margin" of $0.40 to $1.60 hourly pay for operator unavoidable idle time (or .25) for assignments of 16 machines shows a most economic interference - causing work load of approximately 85%. Thus, is appears that the foregoing alternative 2 is the optimum for the product under consideration.

The points for the curves in Figure 3 were determined in the following manner: For each point,

(1) A convenient ratio was assumed.

(2) An interference-causing work load was assumed.

(3) The equivalent total machine interference and operator unavoidable idle time for the assumed work load was determined from Tables I and III, respectively.

(4) The machine interference expense was priced in terms of units of expense by multiplying the assumed ratio decimally expressed, by the equivalent total machine interference.

(5) The operator unavoidable idleness was priced in terms of units of expense by merely decimally expressing the idleness percentage for the assumed work load, determined from Table III.

(6) The values of (4) and (5) were totaled to arrive at the total operator and machine idleness expense for the assumed ratio and work load.

(7) Steps (1) thru (5) were repeated for other work loads, keeping the ratio constant, until that involving the least (6) value was determined.

(8) The optimum work load determined in (7) was plotted against the assumed ratio to determine the curve point.

In summary, knowing the ratio between the hourly "margin" and the rate of pay granted for operator unavoid-

(Continued on Page 26)

TABLE III

AVERAGE PERCENTAGE OPERATOR IDLE TIME VERSUS TOTAL PERCENTAGE WORK LOAD OF ASSIGNED MACHINES

No. Machs.	Operator's Total Percentage Work Load* on Individual Attention Basis														
	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
4	52	47	43	39	35	31	28	24	21	18	16	14	12	10	8
5	52	47	43	39	34	31	26	23	20	17	15	13	11	8	7
6	51	47	42	38	34	30	26	23	20	17	14	11	10	7	6
7	51	46	42	38	34	30	26	22	19	16	13	10	8	7	5
8	51	46	42	38	33	29	25	22	18	15	12	10	8	6	4
9	51	46	42	37	33	29	25	21	17	15	12	9	7	6	4
10	51	46	42	37	33	29	25	21	17	14	11	8	6	5	3
11	51	45	42	37	33	28	24	20	16	14	11	8	6	4	3
12	51	45	42	37	33	28	24	20	16	13	10	7	5	4	2
13	51	45	42	37	32	28	24	20	16	13	10	7	5	4	2
14	51	45	41	37	32	28	23	20	16	12	9	6	5	3	2
15	51	45	41	36	32	27	23	19	16	12	9	6	4	3	1
16	50	45	41	36	31	27	23	19	15	12	9	6	4	2	1
17	50	45	41	36	31	27	23	19	15	12	8	6	3	2	1
18	50	45	41	36	31	27	22	19	15	11	8	5	3	1	
19	50	45	41	36	31	27	22	18	14	11	7	5	3	1	
20	50	45	40	36	31	27	22	18	14	10	7	4	2	1	
25	50	45	40	36	30	27	22	18	13	10	7	3	2		
30	50	45	40	36	30	27	22	17	13	10	7	2	1		
40	50	45	40	36	30	27	21	17	12	9	6	1	1		
50	50	45	40	35	30	26	21	16	12	9	5	1			
75	50	45	40	35	30	25	20	16	11	8	4				
100	50	45	40	35	30	25	20	16	11	7	3				

*Figure the work load at incentive pace and exclude deferable "internal" duties (those which can be performed when all machines are producing).

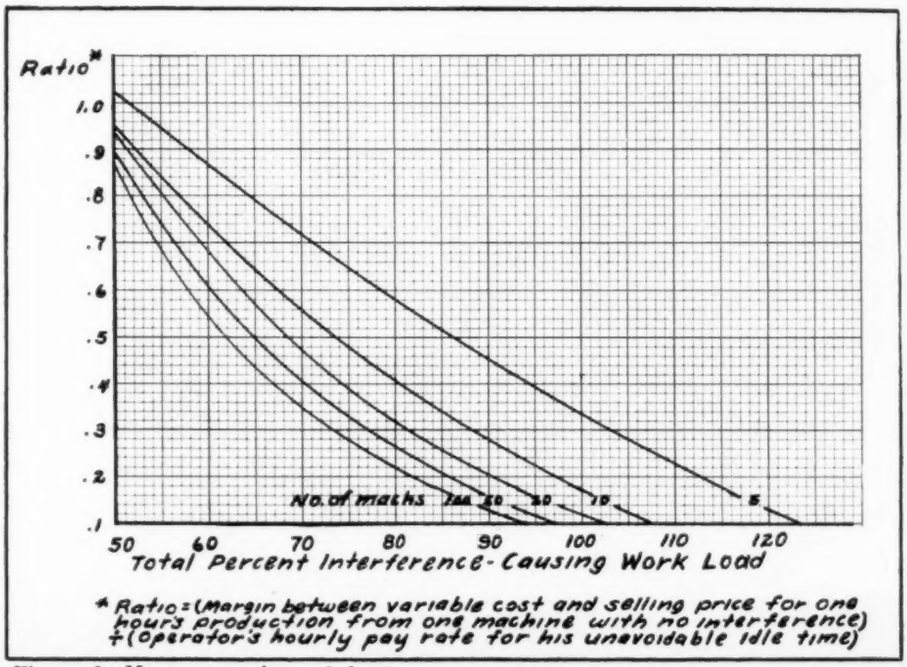

Figure 3. Most economic work load versus machine-operator idleness expense ratio.

PRE-DETERMINED TIME

(Continued from Page 5)

the experimentally determined cutting curves in hand to construct the accompanying table.

In this article the writer has attempted to describe, through use of two examples, methodology employed in efficiently developing and tabulating pre-determined time data. With the tables in hand the engineer is saved the future necessity of having to individually synthesize time standards. It has been pointed out, however, that the time tables thus developed are valid for setting time standards only for the operations whose peculiarities they encompass: it is exceptional when a given standard elemental data table developed in one plant can be used with equal accuracy in another plant.

The experimental approach to setting cutting times described in this article might be regarded as the "scientific method" — the same basic approach employed by Fredrick Taylor in the development of high speed steel metal cutting tools. Our experience has shown that this is the only means by which engineers can set consistent standards when confronted with such questions as "How fast should the operator feed the material or the cutting tool?" or "How much pressure should be applied to the piece during buffing—and for what period of time?"

In closing, the writer would like to emphasize that through skillful use of pre-determined time data and carefully conceived and conducted experiments, one can develop elemental formulae and then tables which will permit the setting of labor standards with an exceptionally high degree of precision.

ROUTER CUTTING STANDARDS IN HOURS PER 100 CUTS
(Includes Bit Changing and Standard Allowances)

To compute cutting time at least one value must be taken from each of the following charts, except when boring where chart XXXV only will apply.

XXXV. BIT ENTRY AND EXIT

This chart covers the lowering and raising of the bit (when necessary) either into the wood or to the correct depth outside of the wood, **plus** the applying of pressure to cut into the edge of a piece and the disengage which occurs when cutting out of a piece.

	ENTRY	EXIT	
	Bit Locked	Bit Raised **Out** of Piece	Bit Raised **Outside** of Piece
Bit Locked at Cutting Depth	.020	——	——
Bit Lowered **Into** Piece	——	.040	.046
Bit Lowered **Outside** Piece	——	.050	.055

NOTE: When quality factor is greater than 1.00, Add .008 hours per 100 to the above chart values.

XXXVI. TIMES FOR EACH CUT BETWEEN CHANGES OF DIRECTION FIRST PASS
(See Note Concerning D/B**)
(QUALITY FACTOR *OR D/B** (WHICH EVER IS LARGER))

Length Of Cut	For All Diameters of Bit Except ⅜"					For ⅜" Bit Diameter				
	1.00	1.25	1.50	1.75	2.00	1.00	1.25	1.50	1.75	2.00
1"	.005	.006	.007	.008	.010	.004	.005	.006	.007	.008
2"	.012	.015	.018	.021	.024	.010	.013	.015	.018	.021
3"	.016	.020	.024	.028	.032	.014	.017	.020	.024	.028
4"	.021	.026	.031	.036	.041	.018	.022	.027	.031	.036
5"	.024	.030	.037	.043	.049	.021	.027	.032	.037	.043
6"	.027	.034	.041	.048	.054	.024	.030	.036	.042	.048
7"	.030	.038	.046	.053	.061	.027	.033	.040	.046	.053
8"	.033	.041	.050	.058	.066	.029	.036	.043	.051	.058
9"	.036	.045	.053	.062	.071	.031	.039	.047	.054	.062
10"	.038	.047	.057	.066	.076	.033	.041	.050	.058	.066
12"	.043	.053	.064	.075	.085	.037	.047	.056	.065	.075
14"	.047	.059	.071	.083	.095	.041	.052	.062	.073	.083
16"	.052	.066	.079	.092	.105	.046	.057	.069	.081	.092
18"	.057	.072	.086	.100	.114	.050	.063	.075	.088	.100
20"	.062	.078	.093	.109	.124	.054	.068	.081	.095	.109
22"	.067	.084	.100	.117	.133	.058	.073	.088	.102	.117
24"	.072	.089	.107	.125	.143	.063	.078	.094	.109	.125
26"	.076	.096	.115	.134	.153	.067	.084	.101	.117	.134
28"	.081	.104	.122	.142	.163	.071	.089	.107	.124	.142
30"	.086	.108	.129	.151	.172	.075	.094	.113	.132	.151

XXXVII. FOR EACH CUT TIME TAKEN FROM ABOVE CHART, ADD APPROPRIATE TIME FROM CHART BELOW:

Weight of Form + Piece	(Quality Factor*)				
	1.0	1.25	1.50	1.75	2.00
0-30#	.008	.010	.012	.014	.016
30#-50#	.015	.019	.022	.026	.030
Over 50#	.023	.028	.034	.040	.045

*Quality Factor = 1.00 For Construction cuts, Minor Tearouts allowed.
= 1.25 For minor quality, extreme dimensional accuracy, etc.
= 1.50 For partially exposed cut.
= 2.00 For extreme quality—usually a decorative cut.

**D/B = Depth of cut divided by diameter of Bit. Allow to nearest .25, + or —

NOTE: **ON SECOND PASS, D/B IS ALWAYS 1**

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MULTIDICIPLINARY ANALYSIS

(Continued from Page 9)

it has control over "all" activities at "all" times. This notion implies that control is *static*, whereas in reality *control is a dynamic process*. Another reason may be found in a lack of desire for dynamic control which might be a consequence of a specific goal-emphasis.

Consequences of the failure to develop dynamic control techniques and practices are demonstrated in many ways in many organizations. For example, the repetition of similar mistakes on the execution levels; the absence (or inadequacy) of selective and evaluative personnel practices; the development of sales potentials; a rising trend in the break-even point; or in the condition of decision-making procedures (such as estimating).

In conclusion, it is pointed out that organization is primarily a *frame of mind*, an orientation. An organization chart with the supporting organization manual provides the *structural* framework for organization, but in itself does *not* accomplish *functional* organization. One way of accomplishing functional organization in an operational setting is suggested:

1. Define and publish the company's basic goals;
2. Establish criteria for evaluation in terms of goal-achievement;
3. Determine [by systematic study] the structural - organizational needs of the company to achieve stated goals;
4. Produce a structural [static] design of the organization;
5. Define and publish each job in terms of authority, responsibility, etc.
6. Apply criteria for *continuously* evaluating the effectiveness of the structural organization, and of the individuals and groups comprising it, and finally
7. Perpetually utilize the [so established] feed-back mechanism to convert the *static design* into the *dynamic process* of organization.

It will now be increasingly possible for the organization-as-a-whole to meet the ever-changing challenges, to adjust less painfully to the ever-changing requirements, and to permit changes at any stage in the process as they may become necessary for basic goal attainment because the process [which is the company-as-a-whole] has assumed a *self-improving* quality.

---

[1]The team consisted of the following members: R. L. Ackoff [methodology (Case Institute of Technology)], R. P. Bullock [sociology (The Ohio State University)], M. B. Creelman [clinical psychology (Western Reserve University)], A. H. Gepfert [operations research (Case Institute of Technology)], C. H. Hollister [market research (Case Institute of Technology)], H. R. Nara [engineering (Case Institute of Technology)], Anatol Rapoport [communication theory and general semantics (University of Chicago)], and W. B. Shimp [industrial psychology]. The author serves as research director.

[2]*Democracy* is usually defined as as administration (or government) which is delegated by and responsible to those who are governed. No industrial organization can be entirely democratic in this sense. Administrative authority is delegated by stockholders to management which is responsible to the stockholders rather than to those over whom the executives hold administrative authority. This does not imply, however, that industry cannot be democratic in the sense that the needs and wishes of those governed are considered and that policy is determined on the basis of the *greatest good for the greatest number.*

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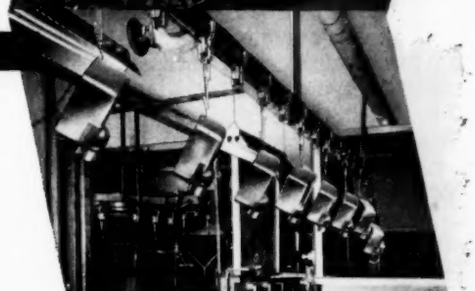

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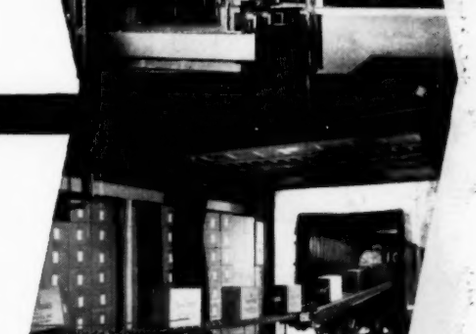

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PROCESS ALLOWANCES

(Continued from Page 11)

TYPE IV—Idle—Dependent—Fixed Limit

Example: Machining element with power feed but operator is idle during element.

These three types of elements are frequently encountered in industrial work and will be discussed together because of their similarity. Such elements are dependent or controlled and are limited as to cycle time. The difference between these three types is the demand made on the operator which ranges from zero to more than 100% demand.

To decide the process allowance for these types of elements involves an important decision of policy. This is emphasized when the extreme condition of idleness is considered. Should a bonus be paid when an operator is idle? Two arguments can be offered. First, a bonus is justified to maintain production, and second, in fairness to the employe he should be given some opportunity to earn a bonus if others have such an opportunity. Since the characteristics of operations are different, as shown by the types of elements discussed here, it is impossible in most plants to provide an equal bonus-earning opportunity to all employes. In recognition of this, it should be the objective of the company to establish a policy which is as equitable as it is possible to devise.

If unavoidable idleness is involved and if a bonus is to be paid, the next thing to be established is the amount of the bonus or allowance. To arrive at something that seems logical and fair, let us consider five possible conditions for a machining element which is controlled as to time, say, one minute.

Condition	Opr. Work	Opr. Idle	Machine Time
(a) Operator is idle during machine time.	0	1	1
(b) Operator is assigned to work which can be completed before machining is completed if operator works with normal effectiveness. He will then be idle during the machining time (.60 min. work assigned).	.6	.4	1
(c) Operator is assigned work which can be just completed during the machining time when operator is working with normal effectiveness. (1 min. work assigned)	1	0	1
(d) Operator is assigned work which can be completed during machining only if operator's effectiveness is above normal but less than average incentive pace (1.20 min. work assigned, assumes average incentive pace is 130%).	1.2	0	1
(e) Operator is assigned work which can be completed during machining time only if operator's effectiveness is above the average incentive pace (1.40 min. work assigned, assume average incentive pace is 130%).	1.4	0	1

It should be quite obvious that element (a) cannot be treated the same as element (e). In one case the operator is working with an effectiveness or effort of zero and in the other case the effectiveness is 140%. Since the elemental time is fixed at 1 minute, a process allowance must be used to provide the opportunity to the operator to earn a bonus in any of these situations. Consider ing the last case first, what should the bonus be? Obviously it should be at least 40%. This, therefore, would constitute the process allowance; that is, the time allowed for the element would be 1.40 minutes. If the operator is unable to maintain this pace of 140%, production will decrease in proportion because of the waiting time of the machine for the operator.

Should this same reasoning be applied to element (d)? In this element the work load assignment is 120%, so the allowance would be 20% if the same procedure is followed. For a 120% assignment this might appear to be satisfactory, but if the work assignment is reduced such that it approaches 100% as in element (e), then what would constitute a satisfactory bonus opportunity? Should it be zero at 100% work assignment? It was previously stated that it would be desirable to provide a bonus opportunity for elements similar to (a) in which the operator is idle. The difference between the work assignment and 100% for work assignments above 100% does not, therefore, seem to be satisfactory.

To provide equitable treatment for these various cases, the following allowances are suggested.

Element (a) — .5 × (average incentive pace —100). Assuming average incentive pace of 130%, the allowance would be 15%

Element (b) — $\frac{\text{Operator demand}}{\text{Ave. Incentive Pace}}$ × (Average incentive pace —100), with a minimum of 15%.
For an assignment of 60% the allowance calculation would be:
60/130 × (130—100) = 13.8%
since this is less than the minimum, 15% would be used.

Element (c) — Same as for element (b). For an assignment of 100% the allowance would be:
100/130 × (130—100) = 23.1%

Element (d) — Same as for (b). For an assignment of 120% the allowance would be:
120/130 × (130—100) = 26.7%

Element (e)—Operator demand —100 when the demand is above the average incentive pace. For an assignment of 140% the allowance would be 40%.
To summarize in terms of the elemental types we have:

TYPE II — Manipulation — Dependent—Fixed Limit
% Allowance: When operator demand is between 100% and average incentive pace:
(Oper. demand/ave. Incen. Pace) × (Ave. Incen. Pace—100)
When demand is greater than average incentive pace: Operator demand —100%

TYPE III—Manipulation and Idle—Dependent—Fixed Limit
$\%\ \text{Allow.} = \frac{\text{Operator demand}}{\text{Ave. Inc. Pace}} \times$ (Ave. Inc. Pace —100) with a minimum of .5 × (Ave. Inc. Pace —100)

The factor of .5 for Types III and IV was arbitrarily chosen by the writer. Any other factor between .3 and .6 would probably give satisfactory results. The selection of this factor would be governed by the average incentive pace, past practices of the company, and other considerations.

TYPE V—Manipulation—Dependent —Variable Limit
Example: A line assembly operation, completely manual, which is dependent on the preceding operation which is also completely manual, and therefore not limited as to time. Both operations have the same normal time.
This type of element or operation is

not too uncommon because of the ease by which the dependent operation can usually be separated and changed to a Type I operation. In some cases this is not practical—such as when one operator is helping another. The procedure for this type should be to let the operators work together as a group with the time saved shared between them. In effect this is changing the two operations to a single Type I operation. No process allowance is needed for this type.

TYPE VI. Manipulation and Idle—Dependent—Variable Limit

Example: A line assembly operation, completely manual, which is dependent on the preceding operation, which is also completely manual and therefore not limited as to time. The second or dependent operation, however, has a smaller normal time such that the second operator must wait on the first.

This type of operation is not too uncommon and is mostly commonly encountered when two or more operators have to work together. It is possible to eliminate the waiting time in the dependent operation if the first operator works with a sufficiently higher efficiency than the second operator, but in no case could the second operator earn as much as the first. This would justify a process allowance. The most equitable treatment for the dependent operation seemingly would be to pay a proportion of the bonus earned on the independent operation. This proportion would be the ratio of the normal time of the dependent operation, excluding idle time, to the normal time of the independent operation. The following example will show how this would apply:

Normal time for the independent operation is 1 minute

Normal time for dependent operation, excluding idle time is .60 min.

The operator on the independent operation works with an efficiency of 125%, thus his bonus amounts to 25%

Ratio: Dependent operation to Independent operation=.60/1.00

Bonus for dependent operation:

$$\frac{.60}{1.00}\times 25 = 15.0\%$$

With this procedure no process allowance would be used in establishing the standard. The operator on the dependent operation would not earn a bonus unless the operator performing the independent operation earned a bonus. This procedure is not too satisfactory in that bonus calculations for the dependent operation cannot be made until the performance of the other operator is determined. If this is not objectionable, this procedure should be satisfactory. An alternative method which gives the same results is to pay the normal waiting time as day work. In the above example this would amount to 3.20 hours per 8 hour work period and would be a constant regardless of the number of pieces turned out.

An alternative procedure which includes a process allowance in the standard would be to use a method familiar to that given for Type III element.

The formula for this allowance is as follows:

$$\%\ \text{Allowance} = 100 \times \left[\frac{(1+\text{Dem.}\ (\text{Av.Inc.Pace} - 1)) - 1}{\text{Av.Inc.Pace} \times \text{Demand}}\right]$$

or

$$100 \times \left[\frac{1}{\text{Av.Inc.Pace} \times \text{Demand}} + \frac{\text{Av.Inc.Pace} - 1}{\text{Av.Inc.Pace}} - 1\right]$$

This allowance is added to the manual time and not to the normal waiting time.

Example: Normal time, independent operation—1 minute

Normal time (excluding waiting time)

dependent operation—.60 min.

Average Incentive Pace—130%

$$\%\ \text{Allowance: } 100 \times \left[\frac{1}{1.30\times .60} + \frac{.30}{1.30} - 1\right] = 51\%$$

Process allowance, minutes:

$.60\times .51 = .306$

Standard for operation:

$.60 + .306 = .906$ min.

(The standard for the independent operation is 1.00 min.)

The effect of the allowance is to permit a bonus which is a percentage of the expected average earned bonus. This bonus is based on the normal percent demand of the operation. As applied to the preceding example the normal percent demand of the dependent operation is 60%. With an expected average earned bonus for the dependent operation of 30%, the bonus for the dependent operation is .60 of 30%, or 18%, when the independent operation is performed at 130% efficiency. The relationship of the bonuses for the dependent operation and the independent operation is the same as in the first method given for this type of element, when the efficiency of the independent operation is at the average incentive pace, but is different at all other levels of production. The primary disadvantage of using this process allowance is that the bonus does not start for the dependent operation until the efficiency on the independent operation is above 100%. In the example given this is approximately 110%.

CONCLUSION:

Various types of operations are encountered which are combinations of the six types listed. Such combinations can be broken down and classified according to one of the six types. The breakdown and classification will suggest a satisfactory procedure. This is not always a simple matter, however, because certain combinations have the effect of the cycle time possessing a double restriction. An example will more adequately explain how this might happen.

Operation B is paced by operation A, thus operation B is dependent on A. Operation A however, is a combination of Type I and Type II elements with a normal cycle time of 10 minutes. The breakdown of operation A is as follows:

Unload and load machine (Type I element)—4 min.

Idle during machining Type IV element)—6 min.

Operation B has a normal cycle time of 7 minutes and is also composed of Type I and Type IV elements. The breakdown of operation B is as follows:

Unload and load machine (Type I element)—5 min.

Idle during machining (Type IV element)—3 min.

Since operation B is controlled and dependent on operation A, a balancing delay of 2 minutes is required for operation B. (This introduces a rare type of element not included in one of the six given. It would be Idle—Dependent—Variable limit.) The standard for operation A can readily be determined by considering the type of elements involved. The normal time for "Unloading and Loading Machines" would be 4 minutes. "Idle During Machining" would require a process allowance of 15%, thus the standard for the whole operation would be 10.9 minutes exclusive of other allowances. Establishing the standard for operation B based on the allowance for each element will not give satisfactory results. The standard must be established in the light of its relationship to operation A. Since operation B has the same total cycle time as A, and since the normal work content is 25% greater, the standard should not be less than for operation A. It might be reasoned that since operation B has 25% more manual work, the bonus opportunity

(Continued on Page 25)

(Continued from Page 7)

nated as being satisfactory in their work.

Cashiers' efficiency also appears to be related to performance on learning-ability tests. Clark found a good agreement between the number of correct transactions made per day by cashiers and the kind of scores they earned on learning-ability tests.

Bookkeeping machine operators were rated by their supervisors on productiveness and then given a learning-ability test. A positive agreement was found between their performance on the learning-ability test and their productiveness in operating bookkeeping machines.

In a study of 43 clerical workers, Giese reported that a stenographic test picked out 80 per cent of those individuals who were rated satisfactory in job performance by their supervisors. The test picked 78 per cent of those clerical workers rated unsatisfactory by their supervisors after three months of service.

Training

Training programs in industry are essential but expensive. Some of the expense involved is often due to poor initial selection of the employees to be trained; but, on the other hand, much expense can be attributed to poor methods of training. One study showed that: "Hosiery mill employees with the poorest finger dexterity as measured by a dexterity test cost a company $59 each in minimum make-up before they make the rate, while employees having the best dexterity cost the company only $36.40. This study suggests that tests can answer three questions about training: (1) Who should be trained? (2) Where should training begin? (3) Has training been adequate?

In a different field, Neal Drought, manager of the Personnel Policy and Research Division of the Radio Corporation of America, states: "We have found in our plants that manual dexterity tests greatly reduce training time by screening out slow from fast applicants, particularly in assembly operations."

The Blue-Bell, Inc., reports that a visual screening test in conjunction with dexterity tests increased their efficiency in selecting and training workers 18.6 per cent. They add that these tests "gave a saving of $80.65 on each of 198 employees employed during 1947. They also indicated that turnover figures dropped 5.7 per cent in 1946 and 3.9 per cent in 1949.

The use of a visual screening test in the Shannon Hosiery Mills revealed that 20 to 25 per cent of the applicants could not meet the basic visual requirements set by the plant for full fashion work.

Visual screening tests differentiated well between good and poor producers in the clerical field. Clerical workers rated as high producers by their supervisors were found to have normal vision in 79 per cent of the cases. In contrast to the high producers, the poor producers met the minimum visual standards in only 21 per cent of the cases.

The Dennison Manufacturing Company has reported that every new employee costs them $80 before he or she reaches average production. In a different area, labor turnover was reported to be of great concern to the Milwaukee Electric Railway and Lighting Company because they invest $217 in each new trainman hired. In the insurance field, a representative of the Liberty Mutual Insurance Company told the writer that the training costs of certain salesmen run as high as $1,000, a figure which includes training, salary, the cost of teachers, etc.

Professional and Executive Staff

The general topics presented up to this point touch on some of these important areas of selection, but none is more important than selecting the quality of professional men and particularly the quality of executives who will direct a plant's activities.

A. *Engineers*

The Employment Department of Allis-Chalmers Manufacturing Company takes a very positive stand on the use of tests, as can be seen in the following statement: "However, from tests we have found that there can be a difference roughly in the ratio of as high as two to one in mathematical ability, mental alertness, interests, and personality between engineers, even though they may have been exposed to the same courses at the same college. This statement has been proved by our experience with tests. Our use of standardized tests has led us to definite conclusions concerning the characteristics young engineers should possess before they can hope to reach the greatest achievement in the above fields of engineering."

In a study of 400 engineers Mandell reported that his data proved that superior engineers could be differentiated from inferior engineers by means of written tests. Using job performance as the criterion of success Mandell found the following factors statistically significant in their ability to differentiate superior from inferior achieves:

(1) More engineers rating low in job performance had graduated from high school at age 16 than those rated higher; more of the superior performers were older at graduation.

(2) Significantly higher percentages of those who rated high in job performance were members of honorary academic societies and fraternities than those rated low in job performance.

B. *Chemists*

Aptitude tests also give promise of selecting chemists. Mandell reported that a test covering the broad field of chemistry correlated significantly with job performance.

C. *Key Personnel*

In a study of 375 key personnel in the canning industry Doty and Spears reported that their data showed that the chances were 19 to 1 that the supervisor whose performance was above average was also above average in general intelligence. The chances were 6 to 1 that the supervisor who was below average in intelligence would be rated by his superior as "poor" in the performance of his job.

In another investigation, it was found that in comparing the productivity of high and low departments, supervisors of the most productive departments (1) were more general in their supervision—they gave employees more chance to exercise initiative, (2) spent less time in actual production, (3) were more employee centered in their thinking, more democratic, liked dealing with people.

Summary

1. More adequate steps need to be taken to evaluate manpower at all levels of industrial placement.
2. Psychological tests, when used properly and evaluated against carefully selected criteria, can generally pay their own way and often save money besides.
3. Industrial use of psychological tests is increasing. Larger companies are leading the field in applying tests.
4. Psychological tests can, if carefully used, select faster learners and hence reduce training costs.
5. Aptitude tests increase the ability of management to transfer employees with greater success. Promotions can be made on a sounder basis by using tests.
6. Tests can select key personnel and engineers who perform in a superior manner.
7. Superior supervisors appear to be more intelligent, more democratic, and more interested in people than supervisors rated as inferior by their bosses.

Quality control in the manpower field is not only possible; it can be done with profit.

PRESS AGENT

(Continued from Page 12)

The Editor Will Help You

A given article may fit best into one magazine, but also be appropriate to another. Knowing in advance just what magazine will publish it helps greatly toward tailoring the article to exactly suit the particular magazine's needs. That is where cordial relations with the editor help out.

Make the best decision you can and then write the chosen editor for advice and comment. Tell him in a letter, perhaps with a rough outline, just what you propose to furnish. The editor also likes to know something about the author, what are his qualifications and experience. Such information helps greatly in editing. Extra careful checking of parts of the article where the author's experience is weak will avoid errors. The editor will answer you promptly telling you whether or not he is interested. Don't expect him to "buy a pig in a poke," however; he must see the final article before he can promise to use it.

How to Write

It is indeed difficult to tell you how to write. However, it can be said in all sincerity that *you can write*.

Basically you need meet only three requirements:

(1) Have something worth writing.
(2) Write clearly.
(3) Write it accurately.

Beginners will do best by setting out to give the editor all information needed for the article, rather than try write it in completely publishable form. That line of approach relieves the tension and promotes clear thinking.

I have a good friend that is a long time belting salesman. He used to come in and visit and give me all kinds of valuable help. But whenever he prepared an article for me, even I couldn't understand it. I had about given up any hope of ever getting his valuable power transmission knowledge on paper, until one day I received a letter from him. It seems the old gentleman was stranded in a small Tennessee town by a snowstorm. The tavern was oppressive and to relieve the monotony he wrote me a long letter telling his experiences — the troubles he encountered and how he cured them. We published the letter as an article and didn't have to change a word. His explanations were crystal clear.

It is not necessary to go into detail regarding outlines, sentence structure, and form. There are a few mechanical details, however, that will help you to save the editor time and money, and consequently increase your pay check:

(1) Never crowd your manuscript pages. Leave wide margins and room between the lines for the editor to do his stuff.
(2) Furnish material for illustrations if at all possible.

Photographs are fine—but they must be good photographs. The editor, engraver, and printer cannot do very much to improve bad photographs if you are going to send them at all. But good pictures are expensive and it is not necessary to send many. Usually two to five illustrations will be sufficient to illustrate four to five magazine pages.

Mechanical drawings make excellent magazine illustrations, but frequently they require special preparation for best effect. Usually it is best to supply these as good clear pencil sketches so that the staff artist can readily make finished copies suited to reproduction requirements. In the case of more elaborate drawings, however, it is well to send blueprints or photostats and let the editor know that the originals will be loaned if requested. The editor's greatest difficulty with large drawings is fitting them to magazine page space. The engraver can reduce the size but if the original is too large, detail is lost through great reduction and lettering may become illegible.

Informative tables are also very desirable, but here again they must be fitted in 7″ x 10″ spaces. A little consideration to page size on the part of the author will help him to furnish illustrations that are usable without expensive revision.

Give the editor good illustrations on a good subject and he will find a way to get the written matter even if he has to take it away from you by brute force.

Summary

We might summarize as follows:

1—Choose a subject from actual experience.
2—Choose a magazine from actual experience.
3—Furnish good illustrations.
4—Tell your story clearly and simply.
5—Make it truth—not fiction.
6—Avoid long introductions and get on with the job.
7—Don't philosophise. Stick to direct helpful information.

Conclusions

I hope I have convinced you that technical writing is a worthwhile avocation for active engineers. It pays, it promotes, and it is a lot of fun.

So I say again, *be your own press agent*. Your wife may love you, but the rest of the world won't know much about your abilities until you put your accomplishments on paper.

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PROCESS ALLOWANCES

(Continued from Page 23)

should be greater than for operation A. It would follow that the process allowance for operation B should be 25% greater than for operation A. This process allowance would amount to 1.125 minutes, thus the standard for operation B would be 11.125 as compared to 10.9 for operation A. From a practical standpoint this might not be too desirable. Operation B would then have the greater bonus earning opportunity which would make it the preferred operation from the operator's viewpoint.

It should be obvious that when situations like the preceding example are encountered, process or method changes should be made to change the operations or elements into types which are more adaptable to incentives. As a general principle elements should be changed into independent — variable elements for greatest effectiveness for wage incentive applications. In conflict with this principle is the general trend toward dependent — fixed limit elements because of technological advancements through the more extensive use of semi-automatic and automatic machines and by the greater use of paced line operations. This trend emphasizes the importance of having well defined policies and procedures pertaining to process allowances.

CRITERIA

(Continued from Page 13)

and the number of accidents. A crane hoist reduces the worker's physical exertion, thus decreasing the necessary rest time. Automatic positioning devices noticeably reduce the eyestrain of many assembly operations.

(8) Some tools perform an otherwise impossible operation. For example, rivets with explosive heads have been successfully used to rivet parts where one end could not be reached.

(9) In the last 150 years, every element of manufacturing cost has been substantially reduced except one, the cost of scrap and waste. It has been reduced some. Usable output in the only output that counts. Thus, a tool which makes more output usable increases productivity. Automatic nailing machines reduce scrap loss in material and nails as well as performing the operation much faster.

(10) If we regard lower cost as a measure of increased productivity, the use of cheaper materials and supplies will increase overall productivity. Of course, the cheaper item must perform as effectively. The use of staples instead of nails has reduced the cost of many packing and shipping items.

(11) If a superior product can be produced without additional expense, we can say that overall productivity has been increased. However, most improvements of this kind come from chemical and metallurgical developments of better materials.

Tools vs. Larger Units

In order to aid in separating productivity tools from larger machine units, three criteria are recommended. They are based on power rating, physical size and cost. Since the difference between the productivity tools and larger units is largely one of degree, any standards must be arbitrary. As a program develops, new and different criteria may be necessary. The suggested criteria are:

1. It is rated at less than one horsepower.
2. Except for material handling equipment, it does not occupy floor space.
3. The cost per unit is less than $500.

Comparison of Tools

In some cases, the administrators of the program must decide between two or more alternative productivity tools for performing the same job. These alternative tools will have qualified under the above criteria. The following five criteria seem sufficient to choose the best alternative.

1. Relative savings.
   a. Pay-off period.
   b. Rate of return on investment.
2. Suitability to organizational customs and attitudes. (The tool should not be contrary to the national law, union work rules, or local customs.)
3. Availability of the productivity tools.
4. Technical soundness of the use.

(1) The first relative criteria is based on the principles of engineering economy. This uses the financial basis for evaluation and assumes that relative worth can be measured by monetary returns. For small tools, the most common method in the United States today is the pay-off period (the length of time necessary for the savings to pay for the investment). Another method compares tools by using the percentage rate of return which the net savings show on the investment.

(2) Care must be taken that proposed tools are not offensive to the persons who will be using them. United States firms have often had trouble with foreign labor because certain tools and methods common in the United States were unacceptable in other countries.

(3) Relative availability of tools must be considered. Equipment which cannot be delivered for months or years would have to be dropped from consideration. Since certain items may be more urgently needed by our own defense program, the supply of them for other uses may be exhausted.

(4) In some situations, technical soundness may favor one alternative over another. The second method may do the job but requires excessive maintenance or constant adjustment.

Undue emphasis should not be placed upon the productivity tools and gadgets themselves. Great savings are possible with no additional tools, simply by rearranging the workplace and the sequence of operations. A systematic analysis of operations based on the principles of motion economy is an essential consideration. With a trained and inquiring mind, the manufacturer can see continual impovements and will know where and when productivity tools may be useful.

Evan Clague, Commissioner of Labor Statistics, United States Department of Labor, has listed five factors in increased productivity:

1. Worker element.
2. Management efficiency.
3. Technology.
4. Level of capacity utilization of machines and manpower.
5. Supply arrangements.

The social and personal problems involved in methods impovements are frequently more troublesome than the technical ones. The right labor and management attitudes in economic policies are important.

GRAPHICAL DETERMINATION

(Continued from Page 19)

able idle time, and the approximate number of machines to be assigned to the operator, Figure 3 can be used to determine the most economic work load to assign to the operator.

LIMITATIONS OF FIGURES 2 AND 3

Figures 2 and 3 represent applied work load determination methods for assignments tended by individual operators. In the case of assignments involving more than one operator, the modifications necessary to use these tools are so involved as to rule out the practicality of their application.

It is apparent that use of the techniques described in Figures 2 and 3 are valid only when the multiple machine assignment labor force is flexible. That is, if, as a result of the application of the techniques described, ten operators are economically justified in one department during a given week, and eleven are economically justified the next week, and ten the following week, etc., the application of the techniques will be uneconomical unless the working force can be varied accordingly. The variation of multiple machine assignment working force inherent in the proper use of Figures 2 and 3 does not necessitate "hiring and firing" at above normal rates: by providing for interdepartmental labor fluidity, by producing standard inexpensive items during periods when otherwise excess labor is at hand, etc., it is possible to avert the undesirable frequent variation of the total labor force.

It is apparent that the assignment of necessary work to be performed during the multiple machine assignment operators' otherwise unavoidable idle time due to work load limitations will reduce the expense of labor idleness. In practice, however, wage rate differentials, limitations of skills, etc., often make this procedure impractical. In the cases where this foreign "internal" work is considered for alternate work load assignment possibilities, idleness pricing adjustments must be made for same on a rational basis when using Figures 2 and 3.

Figures 2 and 3 apparently are not precision techniques for insuring optimum multiple machine assignment work loads from day-to-day. However, it has been found that the techniques described permit substantial savings over the usual arbitrary, "rule-of-thumb" work load determination methods.

Have You Seen This?

MAT SWITCH

The Recora Company, 56 West 103rd Street, Chicago 28, Illinois, announces a new line of Switchmats—extended area electrical switches in the form of sheets or thin mats. Available in any size or shape from 2″ x 2″ up to 36″ x 144″, these SPST switches are actuated by pre-determined pressures ranging from a few ounces to several

tons. Only 3/16″ thick, they can be used on floors, platforms, stair treads, etc., without obstructing foot or vehicle traffic. Foot pressure on any part of the area covered by the mat closes the circuit; release of pressure instantly opens it. Mats are hermetically sealed against moisture and weather between vinyl, rubber or neoprene. Switchmats can handle up to 1 ampere at 110 volts directly, and can control the operation of high voltage, high current devices when used in conjunction with the control boxes also manufactured by The Recora Company. Available controls cover types for temporary and permanent installation and provide instantaneous and delayed action. Typical uses are as versatile foot switches for various industrial and commercial electrical equipment; actuators for automatic door operators; interplant traffic controls, safety and production devices for machine operators; entry alarms; automatic lighting of yards, signs and advertising displays; and for many other factory, institution, commercial and home labor-saving and life-saving applications.

* * *

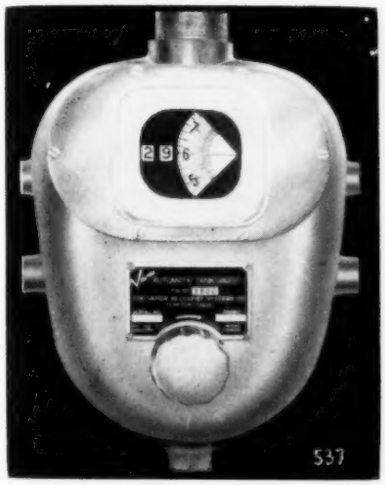
AUTOMATIC TANK GAGE

No oil tank should be considered properly equipped without a dependable, gas-tight automatic Tank Gauge! The new "Varec" Figure No. 2500 Automatic Tank Gauge can eliminate the many errors of hand gauging and will, in addition, permit a host of time and money saving advantages by: reducing vapor losses; minimizing hazards to worker and tank; adding to tank's working capacity by improving pumping and transfer control; increasing overall operating flexibility.

Provisions are made on the Gauge Head for mounting a Mechanical Hi-Lo Limit or Controller Switch for sounding alarms, lighting signals, or as electrical control for pump motors, solenoids, etc.

"Varec" Electronic Remote Reading Gauging equipment and Electronic Hi-Lo Limit or Controller Switches, illustrated in another Bulletin, are also adaptable.

For further information write to The Vapor Recovery Systems Co., Compton, California.

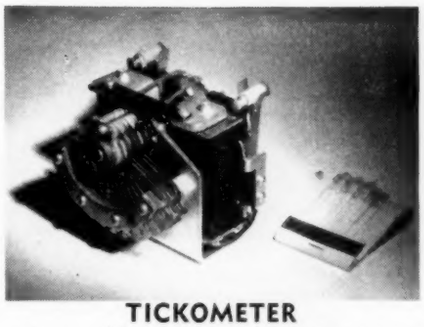


STEPPING SWITCH

Capable of advancing or reversing with equal ease and speed, Consolidated Engineering's new Model 27000 *Bi-Directional* Stepping Switch is adaptable to a wide variety of applications impracticable for conventional switches.

As a differential counter, the unit is used to indicate a remaining quantity or balance on hand, such as in a hopper or processing unit, where each unit inserted advances the switch and each unit taken out or completed reverses it one step. As a remote positioning motor, the switch mechanism can be controlled by bi-directional, remote sources, such as dials or shafts having stops at discrete points. In automatic computers, it can be used as a digit-storage register, a single switch being able to add or subtract over separate control paths. As an automatic attentuator, it is used to add or subtract (through its unique reversibility) resistances for adjusting gain and preventing overloads.

Write Consolidated Engineering Corporation, 300 N. Sierra Madre Villa, Pasadena 8, California, for Bulletin 3004 which contains complete details of the Model 27000 Bi-Directional Stepping Switch.



TICKOMETER

A machine that accurately counts practically anything from dollar bills to World Series tickets at speeds up to 1,000 per minute has been introduced by Pitney-Bowes, Inc., postage meter manufacturers. An optional imprinting device permits dating, coding, endorsing or canceling while counting.

"Tickometers" are already making "tremendous savings" in time and labor, according to PB, in banks, department and specialty stores, utilities and transportation companies, amusement and sporting enterprises, food and drug manufacturers, bakers and brewers, publishers and news distributors.

Among the items handled—at speeds ranging from 500 to 1,000 per minute—are checks and currency, tickets and coupons, labels and cards, stubs and receipts, sales and production slips and even magazine cover "returns."

Its makers say the new "Tickometer" offers "100 per cent counting accuracy," is simple and safe to run, requires no extensive training, and feed and stacks automatically. Its trip mechanism is reported to be so sensitive that it once picked out a counterfeit bill in the middle of a big run of currency at a leading Eastern department store, rejecting it because it was a hair's breadth too thick.

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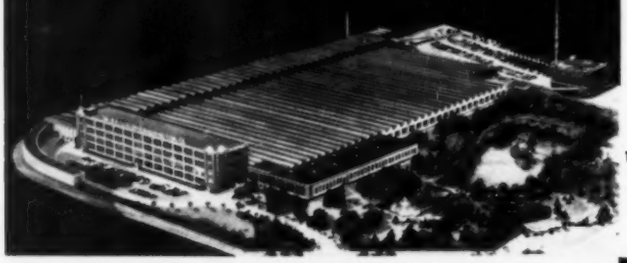

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